JOURNAL

OF THE

ARNOLD ARBORETUM

VOL. XXXVII OCTOBER 1956 NUMBER 4

STUDIES OF THE GENUS COCCOLOBA, II. THE IDENTIFICATION OF COCCOLOBA SWARTZII MEISNER AND COCCOLOBA BARBADENSIS JACQUIN AND THEIR RELATIVES

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IN A STUDY of the genus *Coccoloba* in Cuba published in 1949 (Jour. Arnold Arb. 30: 388–424), I recognized *Coccoloba swartzii* Meisner as a species of *Coccoloba* of wide distribution in the West Indies. A complete understanding of this species and a discussion of its variations and distribution was not possible at that time, despite the fact I was re-establishing a species not recognized for nearly fifty years. In 1950 I made an extensive trip through the Greater and Lesser Antilles to study the distribution and variation of species of *Coccoloba* in the field. In succeeding years I have had the opportunity of field study in the Bahamas and Jamaica. A number of trips to Jamaica to study the plants growing on bauxite soils has permitted the examination of many populations of *Coccoloba swartzii* which is based on material collected in Jamaica. The problems presented by this polymorphic species and its insular variations are not all solved but I hope that this paper will remove some of the confusion currently present in the identification and description of these plants in the West Indies.

I am indebted to the American Philosophical Society for a grant from the Penrose Fund in 1950 which initiated the original field study of the genus *Coccoloba*, to the Institute of Jamaica and, indirectly, to the Reynolds Jamaica Mines and the Kaiser Bauxite Company for additional financial support which made possible subsequent observations of *Coccoloba* while engaged in a field survey of plants on bauxite soils. During the summer of 1955 I visited many herbaria and botanical gardens in Europe and acknowledge with pleasure the permission granted me by the directors and curators of the following herbaria to study critical and related materials in the following institutions: Botanischer Garten und Museum, Berlin-Dahlem; Botanische Staatssammlung, München; British Museum, London; Conservatoire et Jardin botaniques, Genève; Linnean Society of London; Naturhistoriska Riksmuseum, Stockholm; Royal Botanic Garden, Edinburgh and Royal Botanic Garden, Kew. Additional herbarium ma-

terials have been borrowed from many institutions in the United States. I am particularly appreciative of the patience of the directors and curators during the long period that specimens have been on loan from the Gray Herbarium, the Field Museum, the New York Botanical Garden, the University of Michigan and the Missouri Botanical Garden.

Coccoloba swartzii Meisner is the name which must be applied to the common species of the West Indies previously called *C. barbadensis* by Lindau, *C. diversifolia* by Lindau, Fawcett & Rendle and Britton, *C. coronata* by Millspaugh and *C. punctata* by Krebs, Eggers and Northrop. *Coccoloba borinquensis* Britton and *C. urbaniana* are now recognized as one form of this species, while *C. neglecta* Fawcett & Rendle is included within the species concept. As the name *C. diversifolia* Jacq., the name most widely used, must be substituted (Jour. Arnold Arb. 30: 421–424. 1949) for *C. laurifolia* (of all recent floras), a considerable readjustment of nomenclature is necessary in terms of the usage found in the present-day floras of the West Indies.

The name *Coccoloba barbadensis* Jacq. is the oldest name commonly applied to this species in floras in general use. This species was originally described very briefly by Jacquin in his Enumeratio 37. 1760. It listed in synonymy "Guajabasa foliis oblongis" from Houston's catalogue. An illustration of the species was supplied in Jacquin's second report of the species in his Observationum Botanicarum 1: 18, *pl. 8.* 1764; however, the description was not amplified. A specific location for the origin of this plant was not given in either description and this has caused a great deal of the confusion regarding the application of this name. The assumption has been made that Jacquin would have applied the specific name "barbadensis" to a plant from the West Indies, presumably the island of Barbados, and all recent monographers have attempted without success to associate Jacquin's species with specimens from Barbados or one of the islands near Barbados in the Lesser Antilles. In an attempt to identify accurately both Jacquin's plant and its origin, I learned of the earlier similar considerations by Messrs. Sandwith and Dandy and both have been most generous of their time and effort in assisting me. Mr. Dandy has supplied copies of his correspondence on this problem and secured for me photographs of the Jacquin material in the British Museum. However, these observations still did not resolve the problem in my mind and it was clarified only after a visit to the British Museum and personal study of the authentic material. The herbarium of the British Museum contains two sheets referable to Jacquin's herbarium. The original Jacquin sheet, to be considered the type of the species, is the one illustrated in Observationum Botanicarum. The illustration is accurate and the specimen drawn is sterile, being the terminal portion of a shoot, not necessarily an adventitious shoot. Jacquin had only sterile material at the time of publication for he mentions "racemus vero sive floriger sive fructiger desideratur omnis." Although Jacquin was in the West Indies, there is no indication that he collected the material himself. His itinerary included Martinique, St. Vincent, Grenada, Guadaloupe, St. Kitts, St. Eustatius, St. Martin,

St. Barts, Haiti, Jamaica and Cuba, as well as Venezuela and Colombia in South America and the islands of Curacao and Aruba. The known material of *Coccoloba* from these areas does not match the sterile specimen illustrated by Jacquin.

In the herbarium of the British Museum is a second sheet from the Miller Herbarium called *Coccoloba barbadensis* Jacquin which was collected by Houston. Mr. Dandy had written that this specimen possessed an old inflorescence axis without flowers or fruit and that "it is exactly the same as Jacquin's *C. barbadensis* and may possibly represent the same gathering." While this could not be identified by the photograph, personal observation last summer satisfied me that Mr. Dandy was correct in concluding that they are identical. I later discovered still a third sheet referable to Jacquin's species in the herbarium at Cambridge. This also was a Houston collection and also possessed an old inflorescence axis. If the sterile material which Jacquin described came from the Houston collection, as seems apparent, an accurate determination of this species seems possible. Houston visited Cuba and Jamaica, but more important, he visited Mexico and Campeche (Yucatan) in particular. It is among Mexican collections that the type material of *C. barbadensis* Jacquin can be matched with certainty and it is to Mexican collections that the name should be applied.

To Meisner must go the dubious credit of creating all the confusion, for the reference in DC. Prodr. 14: 153. 1856–7 is apparently the earliest reference of the Jacquin species to the island of Barbados. Meisner, however, saw only a sterile fragment in the Berlin herbarium which appears to be an Ehrenberg collection from St. Thomas. At the same time, Meisner described a new variety, *C. barbadensis* var. *mexicana*, based on a collection by *Schiede 1151* from Mexico. Lindau (Engl. Bot. Jahrb. 13: 187. 1890) raised this variety to a species (*C. schiedeana*), referring to it several additional collections. It is among the many collections now called *C. schiedeana* that one finds exact matches of the type material of *C. barbadensis*. *Coccoloba schiedeana* must be considered a synonym of *C. barbadensis* Jacq. and several species more recently described will also be assigned here in a later paper.

Additional support for considering *Coccoloba barbadensis* a species not of Barbados but of Mexico, particularly the Yucatan area, can be found in two companion cases. In Observationum Botanicarum, Jacquin described a second sterile species of *Coccoloba*, *C. emarginata*, which is also illustrated. This is now known as *Neomillspaughia emarginata* (Gross) Blake. Although the name is based on *Podopterus emarginatus* Gross, the species are the same. A second case is the species *Paullinia barbadensis* Jacq. of the Sapindaceae. Radlkofer (Pflanzenreich IV 165: 334. 1931) recognizes this Jacquin species as occurring only outside of Barbados, although it has the same specific name *barbadensis*. Finally, the assignment of *C. barbadensis* to Mexico is supported by applying proper emphasis to Jacquin's citation of a reference to Houston's catalogue in the original description.

In his monograph of the genus *Coccoloba* (Engl. Bot. Jahrb. 13: 148. 1890), Lindau recognized *C. barbadensis* Jacq. (Enum. 37. 1760 and Observ. 1, 18, *t. 8*) and listed in synonymy with it *C. diversifolia* Jacq. (Hist. Stirp. Am. p. 114, *tab. 76.* 1763 & Pict. *tab. 113.* 1780). However, in a treatment published in Urban's Symbolae Antillanae (1: 223. 1899) he cited new references and reversed his treatment of these two names, accepting *C. diversifolia* Jacq. (Enum. 19. 1760) and placing in synonymy *C. barbadensis* (Enum. 37. 1760), apparently on the basis of page priority. In this treatment he has been followed by Britton and his co-authors in treatments of the genus, for The Bahama Flora and the Flora of Puerto Rico and the Virgin Islands, as well as Fawcett & Rendle in the Flora of Jamaica. As *C. barbadensis* must now be used for a Yucatan species and as *C. diversifolia* Jacq. must be applied to the West Indian species with pedicelled fruit generally called *C. laurifolia* (Jour. Arnold Arb. 30: 423. 1949), it should be clear, therefore, that *C. barbadensis* Jacq. and *C. diversifolia* Jacq. are not identical and the synonymy used in current floras is incorrect. Further, as neither name can apply to the West Indian common species under consideration, a new name must be found.

The names *Coccoloba punctata* and *C. coronata* which some authors have used for this species are not available, as both are referable to *C. venosa* L. (Syst. Nat. ed. 10, 1007. 1759). *Coccoloba punctata* L. was published in the second edition of the Species Plantarum, page 523. 1762 and *C. coronata* Jacq. (Hist. Am. Stirp. 114, *tab. 77*) is based on an erroneous Plukenet illustration, the fruits of which are not *Coccoloba* and the leaves represent the validly published *C. venosa* L.

The next available name is *Coccoloba swartzii* Meisner (DC. Prodr. 14: 159. 1856–7) which was based on specimens in the DeCandolle herbarium at Geneva collected by Swartz, West and Forsyth. The description given applies primarily to the Swartz material and it is apparent that Meisner considered this the type specimen, although there is no published indication of such a decision. The Meisner personal herbarium is at the New York Botanical Garden and a fragment of the Swartz specimen from the DeCandolle herbarium was selected as representative of the species. Although none of the specimens cited by Meisner is given a specific island reference, it is probable that the Swartz material was from Jamaica, the "Forsyth" material (in reality that of Dr. Wright) also from Jamaica and the West material from St. Croix. Specimens in the collections at Stockholm, Berlin and Copenhagen match those cited by Meisner and carry more complete information. Modern collections which match the Swartz type of this species are all from Jamaica; e.g. *Harris 5500, 8062, 11639*; *Britton 430, 919, 3236, 3757* and *Howard 12022, 12031.* Fawcett and Rendle cite some of the specimens recently mentioned in their treatment of the genus *Coccoloba* for the Flora of Jamaica. However, they overlooked the species described by Meisner and call the material *C. diversifolia* which is here referred to *C. swartzii.* Lindau recognized *C. swartzii* of Meisner but distinguishes this from his *C. barbadensis* by the absence of pubescence on the rachis.

I am referring to *Coccoloba swartzii* material from St. Lucia and other islands to the north in the Lesser Antilles, as well as collections from the Leeward Islands, the Virgin Islands, Puerto Rico, a few specimen from Hispaniola and Cuba and material from Jamaica and the Bahamas. I have studied living plants in each of the areas designated and have examined over 150 different collections as herbarium specimens. On the basis of comprehensive field studies, to develop the background for interpretation of the older herbarium specimens, I have concluded that *Coccoloba swartzii* is a polymorphic species with considerable morphological variation present in individual plants, populations and geographic areas. The type material of the species can be considered as one end of a line within the species and is not typical nor characteristic of the species from the consideration of its geographical entirety. As is usual in *Coccoloba*, the plants are functionally unisexual and in *C. swartzii* in particular the difference in aspect between the functionally staminate plants with clustered flowers and the functionally pistillate plants with generally single flowers is striking and has been valued much too highly in establishing species characteristics. The morphological variation present in *C. swartzii* in the development of adventitious shoots both following injury and without injury is also striking. A tree of this species on the island of Nevis, in a protected and cherished bit of woodland, was about the largest tree on the island. This specimen was fully eighty feet tall and had a diameter of three feet at breast height. The first branch was fifty feet above the ground and nearly a foot in diameter at the trunk. Twenty feet from the main trunk there arose from this horizontal branch an erect shoot with the larger leaves, long internodes and ochrea typical of adventitious shoots. The leaves were three or four times the size of the leaves on all the other branches and parts of this plant. There was no apparent injury responsible for the development of this shoot which, if taken alone, would have represented material clearly distinct from the main tree.

Another tree in a river valley near Casa Pilota on Martinique (*R. A. & E. S. Howard 11712*) possessed adventitious shoots which bore leaves 70 cm. long and 25 cm. broad. These were the largest adventitious leaves on one of several trees in the area which had been partially cut for firewood. The tree in question had branches with round leaves averaging 10 × 8 cm. and from the base of one of these branches the adventitious shoots with the larger leaves were developed below the scar of a machete cut. Without field knowledge of these plants, the proper interpretation of many of the specimens in herbaria has been faulty.

The variation in leaf size and shape, even without the effects of trauma, are sufficient to create difficulty for the herbarium taxonomist. Additional variations are possible in thickness, texture and aspect of the leaves when dry. An example of this is *C. neglecta*, described by Fawcett & Rendle in the Journal of Botany (**51**: 124. 1913). *Harris 5094* was cited as the only specimen. Shortly after the paper appeared, Urban apparently suggested the Harris number was a mixed collection, for in the herbarium at Berlin is a letter from Fawcett to Urban acknowledging that the leaf of *Harris 5094*

which Urban had sent was actually *C. diversifolia* (e.g. *C. swartzii*). Thus in their later treatment of *C. neglecta* for the Flora of Jamaica, Fawcett & Rendle cited "Harris 5094 in part" and also *Harris 5233*. I have seen five sheets of the type number and three sheets of *Harris 5233*. I can only conclude that the *Harris 5094* is not a mixed collection as Urban and Fawcett & Rendle supposed, but only variations to be expected within one collection, even from a single tree of this species. Fawcett & Rendle distinguish *C. neglecta* from *C. swartzii* by the fact that the former has inconspicuous veins and the latter more conspicuous veins in the leaves, in dried condition. This character reflects only the variation in thickness of the leaves. The character of pubescence altered in successive published descriptions of this species is likewise a variable character and is not supported in the specimens I have seen or those cited by the authors. *Coccoloba neglecta*, here reduced to the synonymy of *C. swartzii*, is another example of the variations present in this species which become exaggerated in isolated herbarium specimens.

The variations in leaf shape are particularly evident in the aspect of the leaf base. Plants from Jamaica, the Bahamas, Hispaniola and Puerto Rico tend to have an oblique cordate leaf base. Those from the Lesser Antilles tend to be cuneate at the base. Specimens from Jamaica, Hispaniola and Puerto Rico tend to dry a characteristic dull black color, while those from the Virgin Islands become bright yellow-green and glossy when dry; those from the Lesser Antilles are neither black nor glossy but dull grayish green. The collections from the Bahamas and the Virgin Islands have consistently smaller leaves. Specimens which I collected in South Bimini of the Bahamas have leaves as small as 2 cm. long and 1 cm. wide grading on the same plant and in the same population to plants with leaves comparable to those of plants from Jamaica. The length of the inflorescence varies with the size of the leaf. Lindau has annotated many of the herbarium collections cited from the Bahamas with an unpublished variety name referring to the small leaves.

There is substantial variation also in the size and some variation in the shape of the fruit. So few specimens are represented by fruit, however, that it is impossible to evaluate the associated characters. In general, the fruits are larger in specimens coming from the Virgin Islands and the Lesser Antilles than they are from the northern and western ends of the range.

I have recognized two forms of this species, forma *pubescens* and forma *urbaniana*. Each is recognized for a different reason. *Coccoloba swartzii* forma *pubescens* is discussed in more detail later in this paper. This taxon includes plants retaining pubescence into maturity and specimens have been assigned here from Cuba, Guadeloupe, Barbuda and Antigua.

Where possible in the field, I have studied germinating seedlings of all species. Seedlings of *C. swartzii* were most abundant in St. Lucia where, under a thirty-foot tree on a dry hillside between Le Toc and Cul de Sac Bay, I discovered the ground littered with old and new fruits, with a fair percentage already germinated. A specimen was made of the parent tree

(*R. A. & E. S. Howard 11377*) and the young seedlings. The cotyledons were still contained within the fibrous fruit coat and vascular remains of the hypanthium. A tap root was well developed. The hypocotyl, petioles of the cotyledons and the apical bud were densely long-pubescent, literally pilose-pubescent. A few older seedlings in the vicinity showed evidence of short hairs, but none of the mature plants revealed a persistent pubescence. Germinating seedlings located beneath plants of *C. swartzii* forma *pubescens* on Antigua are almost identical in the pubescent characteristics. However, in the parent plants of these seedlings the pubescence had persisted. These pubescent plants are recognized as forms because of a scattered occurrence, yet present in sufficient, although localized, numbers to be significant populations.

The second form recognized consists of conspicuous anomalous, perhaps teratological, plants known from restricted areas in Puerto Rico. This taxon is also discussed in more detail later in this paper, but the entity is recognized as a form because its conspicuous character, coupled with its restricted geographical distribution, would suggest evaluation as a geographical variety if the numerous intermediate forms were not known. As the intermediate forms do have a validly published name which cannot be applied to an anomalous condition, it seems desirable to use nomenclature here to indicate the variation recognized within the species.

The variation recognized in *Coccoloba swartzii* is greater than that found in other species of the genus in the same area. *Coccoloba uvifera*, *C. diversifolia*, *C. pubescens* and *C. krugii*, which have comparable ranges, have far greater morphological uniformity. It had been hoped that cytology might offer further light on the nature of the variation seen and to that end extensive collections of fruits and seeds were made and have been received since. However, less than one percent of the fruits proved viable and only two plants were grown past the cotyledon seedling stage from eighty different lots of fruits. Root tip chromosome counts have not been obtained from these, despite numerous attempts.

I strongly suspect that some apomictic methods of reproduction will be found in the genus *Coccoloba* and probably in *Coccoloba swartzii*. The numerous small variations which seem characteristically representative of insular floras in this species are not at present large enough to be taxonomically significant, but are potentially of species magnitude. It is significant also that even the oldest plant distribution records of the species and its variations based on herbarium specimens can be verified today. This is remarkable when one considers the severe population pressures in the West Indian Islands, the effects of hurricanes and the passage of time. In other words, the variations within the species have not been chance collections of botanists in the past, but are definite populations which are being perpetuated. Such small variations, when represented by isolated collections and handled by taxonomists who emphasize minute characters, result in the taxonomic creation of "difficult" genera. *Coccoloba* is indeed such a genus, with relatively few good morphological characters and extremely large variations often involving the same characters.

Other species which could be considered closely related taxonomically to *C. swartzii* are *C. pyrifolia*, *C. microstachya* and *C. krugii*. These are described and discussed for comparison, since material of *C. swartzii* has been incorrectly associated with these species by many botanists and authors.

Coccoloba swartzii Meisner, DC. Prodr. **14**: 159. 1856; Lindau, Engler Bot. Jahrb. **13**: 157. 1890; Howard, Jour. Arnold Arb. **30**: 420. 1949.

Coccoloba swartzii var. (?) *portoricensis* Meisn. DC. Prodr. **14**: 160. 1856; Lindau, Engler Bot. Jahrb. **13**: 157. 1890; Britton & Wilson, Sci. Surv. P.R. **5**: 270. 1924.

Coccoloba barbadensis Lindau, Engler Bot. Jahrb. **13**: 148. 1890, not Jacq.

Coccoloba diversifolia Lindau, Symb. Antill. **1**: 223. 1899 and most recent authors, not Jacq. (Howard, Jour. Arnold Arb. **30**: 421. 1949.)

Uvifera swartzii Ktze., Rev. Gen. **2**: 562. 1891.

Coccoloba neglecta Fawcett & Rendle, Jour. Bot. **51**: 124. 1913; Flora Jam. **3**: 116. 1914.

Coccoloba punctata Grisebach, Krebs, Eggers, and Northrop, not Linnaeus.

Coccoloba coronata of Millspaugh, not Linnaeus.

Trees 8–20 m. tall; branches terete, the youngest puberulent, becoming glabrate, the nodes slightly tumid; ochrea 10–12 mm. long, the basal portion 3–5 mm. long, coriaceous, persistent, the upper portion 5–7 mm. long, membranaceous, deciduous, puberulent to glabrate; petioles attached at the base of the ochrea, 10–18 mm. long, puberulent or glabrate; leaf blades ovate to elliptic, 2.2 × 1.3, 7 × 5, 11 × 9, 15 × 7.5 cm. long and broad, entire, coriaceous, usually turning black on drying, glabrous, pit-like depressions on the upper surface, small glands on the lower surface, the midrib and veins inconspicuous or flat above, prominent below, the primary veins 6–7 pairs, arcuate anastomosing, secondary venation conspicuous, reticulate, the apex acute, often rounded, the base narrowed, rounded or slightly cordate, usually oblique; leaves of adventitious shoots on petioles 1.5–2.5 cm. long, the blades generally ovate to lanceolate, 23 × 8.5, 45 × 18.5 to 70 × 25 cm. long and broad, the apex acute to acuminate, the base rounded; inflorescence terminal, 10–15 cm. long, the rachis glabrous or with glandular exudate, rarely papillose; staminate flowers in clusters of 3–5 flowers with tightly concentric membranaceous ochreolae forming a truncate cylinder after the flowers have fallen; pistillate flowers solitary, the ochreolae erect in flowers, flattened against the rachis in fruit, the bracts ovate, 1–1.5 mm. long, the ochreolae membranaceous 1–1.5 mm. long, the flowering pedicels shorter than the ochreolate, the hypanthium 0.5 mm. long, the perianth lobes 1–1.5 mm. long, the fertile stamens with filaments 1 mm. long; fruit ovoid 8–10 mm. long, 6 mm. in diameter, the perianth lobes 1–1.5 mm. long coronate in fruit.

HOLOTYPE: Swartz s.n. DeCandolle Herbarium, Geneva.

LOCAL NAMES: Redwood (Leeward Islands), saltwood (St. Lucia), boarwood (Jamaica), wild grape, red grape, boarwood (Jamaica), tie tongue, bastard pigeon plum (Bahamas).

ECONOMIC USES: *Coccoloba swartzii* is widely used in the Lesser Antilles and the Virgin Islands as a source of wood for charcoal. In many cases every plant on a hillside had been cut at least once and the adventitious shoots which were developing were carefully pruned and protected for the same eventual purpose. Duss reports the wood to be excellent for construction purposes, but such usage in the French Islands has not persisted.

Jamaica: CLARENDON: Savoy, *Harris 11639* (C, F, GH, NY, MO, US); Peckham Woods, *Harris 11194* (NY, US); Croft's Mts., *Harris 11219* (F, NY, US). MANCHESTER: New Green, *Britton 3757* (NY); Mandeville, *Britton 3732* (NY), *3236* (NY). PORTLAND: Green Ridge, *Eggers 3732* (C); Claverty Cottage, *Harris 5088* (C, US); Mt. Pleasant, Stony Hill, *Harris 11133* (F, NY, US). ST. ANDREW: Hardware Gap near New Castle, *Britton & Hollick 1806* (NY); Clydesdale to Chesterdale, vicinity of Cinchona, *Britton 334* (F, NY); Constant Spring to Bardowie, *Harris 12110* (F, GH, MO, NY, S, US); Port Royal Mts., Content Road, *Harris 5092* (US), *5263* (S, US); Lower Davids Hill, *Harris 5091* (C, US); Liguanea Hills, *Prior s.n.* (NY). ST. ANN: Union Hill near Moneague, *Howard 12031* (GH), *12022* (GH), *12013* (GH), *Prior s.n.* (NY); Mt. Diablo, *Hunnewell 19335* (GH). ST. CATHERINE: Holly Mount, *Harris 8901* (NY). ST. ELIZABETH: Malvern, *Britton 1195* (NY). ST. THOMAS: Bath, *Britton 3492* (NY), *Harris 6055* (F, NY); Green Valley, *Harris 5233* (C, NY), *12126* (F, GH, MO, NY, S, US); Mansfield, *Britton 3556* (NY); *Blue Mts., Harris 5274* (C, US), *5094* (B, BM) (Type of *Coccoloba neglecta*, C, J, US). TRELAWNEY: Oxford, *Britton 430* (NY); Troy, *Britton 919* (NY), *Harris 9094* (F, NY, US). WITHOUT SPECIFIC LOCATION: *Swartz s.n.*, TYPE (G, DC).

Bahamas: ABACO: *Brace 1481* (F, NY), *1697* (NY). BIMINI: South Bimini, *R.A. & E.S. Howard 10164* (GH, NY). CAICOS: North Caicos, *Wilson 7708* (F, GH, NY), *7744* (F, GH, NY). CROOKED ISLAND: *Brace 4658* (F, MO, NY, US). FORTUNE ISLAND: *Rothrock 264* (F, NY). GREAT BAHAMA: *Britton & Millspaugh 2544*, (F, NY), *2396* (F, NY). INAGUA: *Nash & Taylor 909* (F. NY), *1009* (NY), *1014*, (F, NY), *1428* (NY). LITTLE INAGUA: *Wilson 7769* (F, GH, NY). LONG ISLAND: *Britton & Millspaugh 6316* (F, NY); *Coker 520* (NY). NEW PROVIDENCE: *Britton & Brace 231* (F, NY), *324* (F, GH, MO, NY, US); *Britton & Millspaugh 2175* (F, NY); *Degener 18970* (A); *J.I. & A.R. Northrop 143* (F, GH, NY). ROSE ISLAND: *Britton & Millspaugh 2122* (F, NY, US); *Wilson 7900* (F, GH, NY).

Dominican Republic: PROV. PUERTO PLATA: *Wright, Parry & Brummel 472* (GH, US). ALTA GRACIA: *Taylor 414* (NY), *431* (NY, US), *433* (B, NY, US). DISTR. DE SANTO DOMINGO: San Isidro, *Ekman 11014* (S, US).

Puerto Rico: Lago San Jose: *Hioram s.n.* (NY); Maricao, *Sintenis 258* (B, GH, MO, NY, S, US); Dorado, *Britton, Britton & Brown 6741* (F, NY); Cayey to Aibonito, *Britton & Britton 9630* (NY); Monte Montoso, *Britton & Cowell 4125* (F, NY, US); La Estancita, *Eggers 1193* (US); Santurce, *Heller 4666* (A, F, GH, Mich., NY, US).

St. Croix: Salt River, *Thompson 580* (US); Sandy Point, *Raunkiaer 2508* (C); Jolly Hill, *Raunkiaer s.n.* (C); Mt. Eagle, *Thompson 427* (G, NY); Signal Hill, *Ricksecker 448* (F); Water Gut, *Isert s.n.*

Vieques Island: *Shafer 2733* (NY, US).

St. Jan: Mt. Eagle, *Ravn s.n.* (C).

Virgin Gorda: *Fishlock 126* (NY).

St. Kitts: Mt. Misery, *R.A. & E.S. Howard 11938* (GH).

Montserrat: Central Hills, *R.A. & E.S. Howard 11868* (GH), *11866* (GH), *11871* (GH). *11867* (GH), *11872* (GH); Gage's Upper Soufriere, *R.A. & E.S. Howard 11882* (GH); Gardru Gut, *Shafer 323* (F, NY, US), *615* (F, NY, US).

Antigua: Pearn Hill, *Box 975* (US).

Guadeloupe: Bois de Gombeyre, *Duss 3251* (F, GH, NY, US); Bouillante to Pont Noire, *R.A. & E.S. Howard 11843* (G).

Dominica: Salybia, *W. H. Hodge 3404* (GH); South Children Estate, *W. H. & B.T. Hodge 1583* (GH); Antilles near Magot, *R.A. & E.S. Howard 11754* (GH).

Martinique: Casa Pilote, *Hahn 1187* (F, GH, US), *R.A. & E.S. Howard 11712* (G); Trois Islets, *R.A. & E.S. Howard 11731* (GH); Montagnes des Trois Flotz, *Hahn 629* (F, GH); Presquile de la Caravalle, *R.A. & E.S. Howard 11727* (GH), *Egler 39–230* (NY); Mt. Pelee, *Duss* (NY); Diamant, *Duss* (NY).

St. Lucia: Castries-Dennery Road, *R.A. & E.S. Howard 11335* (GH), *11329* (GH), *11355* (GH); Vieux Fort, *R.A. & E.S. Howard 11404* (GH); Gros Piton, *R.A. & E.S. Howard 11506* (GH); Le Toc to Cul de Sac Bay, *R.A. & E.S. Howard 11377* (GH).

Barbados: Turners Hall Wood, *Eggers 7161* (US).

Coccoloba swartzii forma **pubescens** Howard, Jour. Arnold Arb. 30: 420. 1949.

The young shoots, petioles, the lower end of the upper leaf surface, especially on the midrib, the ochrea and the inflorescence rachis, at least at the base, puberulent to pilose pubescent.

Cuba: Oriente prov., Punta Padre, *Curbelo 224* (NY).

Guadeloupe: *De Ponthieu 86* (F).

Barbuda: Martello Tower, *J.D. Beard 372* (A, MO); Codrington Village, *Fairchild 3830* (A, US); *Box 602* (US).

Antigua: Sugar Loaf Mt., *Box 1543* (US), *1544* (US); Orange Valley, *Box 1184* (US); Blubber Valley, *Box 1411* (US, HOLOTYPE), *R.A. & E.S. Howard 11860* (GH), *11985* (GH), *11986* (GH); Pelican Bay area, *R.A. & E.S. Howard 11990* (GH); Carr's Ghaut, *R.A. & E.S. Howard 11994* (GH).

The validity of this form was questioned in its original publication, for at that time I had had little field experience with the group. In 1950 while doing field work in Antigua, considerable time and effort were spent investigating populations of this and other taxa of *Coccoloba* to determine distribution of plants, occurrence of pubescence and the interrelation of species reported from that area. *Coccoloba swartzii* proved to be a common plant on the dry hillsides throughout the island and one that was extensively cut for fuel and poles. It was represented in the full range of morphological variation found elsewhere and the growth forms produced by the influence of woodcutters allowed a full study of anomolous specimens earlier represented in herbarium specimens.

Coccoloba swartzii forma *pubescens* was particularly abundant as a dominant population on the hillsides in the Blubber Valley area. While the pubescent form was observed and collected in many other parts of the island, the extent and abundance of plants in all stages of development in Blubber Valley allowed special study. The pubescence used as the basis for this form was uniformly and characteristically developed on plants of this population. It was not associated, as had earlier been suspected, with teratological or adventitious shoots, juvenile plants, injuries or shade conditions. In the Blubber Valley area, mixing of the typical or non-pubescent form and the pubescent taxon did not occur. In fact, the non-pubescent plants appeared to occur only at the margins of populations of forma *pubescens* and the distribution suggested independent and not intermixing ranges.

The variations in growth of the pubescent form of *Coccoloba swartzii* duplicated those found in the species, as well as those found in other species. For example, the collection *R. A. & E. S. Howard 11990* was made from a tree just below the crest of a hill. Young, vigorous foliage occurred on the lower shaded branches and the leaves were predominantly ovate, acuminate to acute at the apex and cordate at the base. Their texture was thin. Some branches at the top of the tree were exposed to the sweep of the wind and these branches had more coriaceous leaves which were smaller in size and predominately orbicular in shape with rounded apices and rounded and only slightly cordate leaf bases. From the base of the same tree there were three adventitious shoots, two occurring normally and one definitely associated with a machete slash. These three shoots possessed leaves of similar appearance, delicate in texture, brightly colored, lanceolate-ovate in shape and three or four times the size of the foliage elsewhere on the plant. These three collections from different parts of the same tree, mounted on different herbarium sheets most certainly would have been referred to different species by previous workers.

Fruits of the pubescent plants were not abundant and seedlings or germinated fruits did not appear in the numbers encountered in the non-pubescent phase elsewhere. However, all seedlings examined from very young plants to saplings possessed a similar development of pubescence. Likewise, the oldest plants studied retained the pubescence on shoots, at least as long as the leaves remained. With the fall of the leaves the ochreae likewise disintegrate and the stems develop a corky layer with the loss of evident pubescence.

If *Coccoloba swartzii* forma *pubescens* were limited to Antigua, it would merit a varietal status on a geographic basis. It is, however, found on other islands and represented by occasional collections. A single collection by De Ponthieu from Guadeloupe must be referred to this form. Although I looked diligently in many areas of Guadeloupe, I was unable to locate any plants referable here. The range of the form is extended westward by one collection from the Oriente province of Cuba. It has also been collected on Barbuda.

Coccoloba swartzii forma **urbaniana** (Lindau) comb. nov.

Coccoloba urbaniana Lindau, Engler Bot. Jahrb. **13:** 155. 1890 in part, Symb. Antill. **1:** 225. 1899.

Coccolobis borinquensis Britton, Sci. Surv. P.R. **5:** 267. 1924.

Holotype: *Sintenis 1527* (GH).

Puerto Rico: Sierra de Naguabo, Loma Icaco, *Shafer 3448* (NY, type of *C. borinquensis*); *Britton, Britton & Cowell 207* (NY); Sierra de Luquillo, *Sintenis 1527* (F, GH, MO, NY, S, US), *Wilson 213* (F, NY, US), *Gregory 56* (NY), *Britton & Bruner 7665* (NY), *7676* (NY), *Barbour & Gerhart 9729* (NY); Indiera Baja, *Britton & Britton 7228* (GH, NY, US); Camp Dona Juaña, Villalba, *Gregory 64* (NY); Maricao Forest, *Sargent A-13* (US); *R.A. Howard 12602* (GH), *Winters 2213* (A).

Lindau described *Coccoloba urbaniana*, citing four collections, two by Crueger (*2694* & *2692*) from Trinidad and two by Sintenis (*1527* & *1585*) from Puerto Rico. His description, however, is obviously based on the material from Puerto Rico. No holotype was selected at the time. In his second publication of monographic studies on the genus *Coccoloba* in the Symbolae Antillanae, Lindau lists and keys *Coccoloba urbaniana*, but cites only the Sintenis collections. In fact, the two Crueger collections are not cited anywhere in this publication. It appears that Lindau was, in practice, accepting the species *Coccoloba urbaniana* for Puerto Rico by excluding the Trinidad material.

Britton in 1924 described *Coccoloba borinquensis*, selecting *Shafer 3448* as the type specimen. He reports that this collection had been "erroneously included by Lindau in Coccoloba Urbaniana Lindau of Trinidad." The Shafer material was collected in 1914 and I can find no indication that Lindau saw the type specimen at the New York Botanical Garden or any duplicates or fragments of this collection. I can only conclude that Britton was referring to a misidentification and that he had overlooked the later Lindau reference which essentially limits the species to Puerto Rico.

Coccoloba borinquensis Britton has been considered endemic to Puerto Rico and has been collected many times, principally in the Luquillo Mountains and the Maricao National Forest. I have studied several populations of this plant in areas similar to mossy forests where it was most abundant. The species as recognized by Britton is a shrub, or rarely a small tree, and is characterized by anomalous and apparently teratological development of the inflorescence axis and the leaves. Both are enormously thickened in living condition and when dried as specimens. In many specimens the rachis thickens as the fruit develops, so that when the fruit falls, the pedicel is immersed in the fleshy axis tissue and the dried inflorescence axis appears to be deeply pitted. The anomalies in the collections cited are numerous. In collections by Sargent, Wilson and Gregory the axis varies in thickness along its length, being thin, almost tenuous at the base and swollen in the middle and at the apex. Many of the specimens in the collection by Sintenis are thickened and branched at the upper end.

One of the specimens collected by Gregory is flattened and obviously fasciated at the apex.

The leaves likewise show variation of an anomalous nature in both living condition and when dried. Many of the leaves seemed almost succulent when fresh, but thick and heavy rather than coriaceous when dry. The veins vary in the degree of prominence in the specimens cited, but such a character is not taxonomically reliable.

Populations of this plant seen in Puerto Rico and the collections on hand show a definite gradation of the characters Britton used to identify this species into the typical form of *Coccoloba swartzii*. However, the conspicuous nature of the abnormality in the field as well as in the herbarium makes it desirable to acknowledge these Puerto Rican populations as forms.

Meisner described with a query a variety of *Coccoloba swartzii* called var. *portoricensis*. Subsequent monographers and workers on the West Indian flora have been unable to place this taxon. Lindau in 1890 studied a drawing of the specimen Meisner cites and thought it might be related to *Coccoloba diversifolia* Jacq. (*C. laurifolia* Lindau) or *Coccoloba swartzii* Meisner (*C. diversifolia* or *C. barbadensis* Lindau). Meisner did not give the name of the collector and as Britton did not recognize *Coccoloba swartzii* Meisner from Puerto Rico Britton also was unable to associate the variety Meisner described with any other species. I have seen the Meisner material at the De Candolle Herbarium in Geneva. It was collected by C. G. Bertero in 1820. A portion of this collection appears in the material I have on loan from the Missouri Botanical Garden herbarium. The Bertero material typifying *C. swartzii* var. *portoricensis* is intermediate between the anomalous *C. swartzii* forma *urbaniana* and the typical *C. swartzii*. It is easily matched by material from the Dominican Republic collected near Puerto Plata and specimens from Seibo by other collections from Puerto Rico and by some from Jamaica. *Coccoloba swartzii* var. *urbaniana* intergrades through material such as *Coccoloba swartzii* var. *portoricensis* into typical material of *C. swartzii*. The transition is so gradual and yet so complete throughout a number of collections that it is impossible to recognize the Meisner variety as a valid taxon.

Coccoloba × boxii, stat. nov. (or *Coccolobis boxii* Sandwith, Jour. Bot. 78: 97–98. 1940.)

Tree to 8 m. tall; current year's branches cinereous, striate, sulcate, pubescent; ochrea to 1.5 cm. long, densely pubescent, the base persistent, sub-coriaceous, the apex membraneous-evanescent; leaves cordiform-ovate, 11 × 6.5 cm. long, 27 × 17.5 cm. broad, coriaceous, light, midrib pubescent; lateral veins 8–12, slightly prominent; petiole densely pubescent, 0.7–1.3 cm. long; apex obtuse, the base oblique, auriculate-cordate or rounded to nearly evenly cordate; inflorescence solitary, simple, 17–22 cm. long; rachis 1.5–2 mm. wide, sulcate, densely minutely pubescent, nodules 1–4 flowered, the bracts broadly triangular-ovate, rounded-obtuse, 1.3 mm.

long, 2 mm. wide, conspicuously pubescent, the ochreolae 2 mm. long, membranaceous, flaring, almost bilobed, glabrous at the base; pedicels to 0.75 mm. long, the hypanthium 1.3 mm. long, the perianth lobes ovate-obtuse, 2 mm. long, 1.75 mm. broad, the interior smaller, the filaments (in bud) 0.6 mm. long; ovary ovoid-ellipsoidal 2.3 mm. long, 1.3 mm. in diameter, glabrous; styles shorter than ovary about 0.75 mm. long.

Antigua: Pelican Bay, *Box 539* (BM, US), *1497* (HOLOTYPE — BM. US).

In the original description of this species Mr. Sandwith reported, "Mr. Box writes that there was only a single tree, about 25 feet high, in this locality, but that he has noted others which appear to be conspecific in a few other stations in the central region of Antigua, *e.g.*, near Piccadilly and at English Harbour. It is a small, much stunted and distorted tree, presenting characters which would suggest a hybrid between *C. diversifolia* and *C. uvifera*, both of which grow in the coastal thickets at Pelican Bay. The tree is easily recognized in the field by the broadly cuspidate-acuminate leaf which somewhat resembles that of the Jamaican *Coccoloba litoralis* Urb."

"It is possible that *Coccolobis Boxii* may represent a hybrid between *C. diversifolia* and *C. uvifera*. The latter species would contribute to such characters as the thicker branchlets with persistent bases of the ochreae, the deeply cordate base of the larger leaves, their venation and texture, the shortly pedicellate flowers, and, perhaps, the indumentum of the branchlets, ochreae and the rhachis of the inflorescence. It is unfortunate that the male perianths have all fallen, and that it is impossible to estimate the length of their pedicels. Again, there are no fruits present on the material, but the single ovary that was dissected bore an apparently healthy ovule. I do not think that the evidence for treating this very distinctive-looking plant as a hybrid is quite conclusive, and prefer to describe it provisionally as a new species."

On the labels Box has indicated that collections *539* and *1497* are from the same tree, although at different times, the former in February and the latter in July. Box also reported that this tree was growing on the seashore with *C. uvifera* and his collection *975* which is *C. swartzii* (*C. diversifolia* Sandwith).

In 1950 I visited the Pelican Bay area of Antigua in the hope of locating the specific plant from which Box had collected the material cited above. In addition to specimens of *Coccoloba uvifera* and *C. swartzii*, I also found the pubescent form which I had described previously, *C. swartzii* forma *pubescens*. Careful study was given to all the plants seen, but I was unable to locate a tree answering to Box's description or which would yield specimens to match the type collections.

Sandwith had seriously considered the possibility of hybrid origin of these plants and, as reported above, decided that the evidence was not conclusive and so described the species provisionally. He further stated in the opening paragraph of his paper that "there is a possibility of hybrid origin. I have been unable to trace any evidence of hybridity between

species of this large genus, but this is not surprising when we consider how rarely hybrids are recorded from the tropics, although there is no reason to suspect that they occur less frequently there than in temperate regions where they become a favorite *deus ex machina* for the solution of botanical difficulties. Only the prolonged residence in tropical countries of such careful and enthusiastic observers as Mr. Box will enable the taxonomist to deal satisfactorily with variable and critical plants collected in those areas."

The taxonomist who proposes a hybrid origin for the species in question is put on the defensive by Mr. Sandwith's comments. However, several factors now count in the writer's favor. In 1940 when Mr. Sandwith wrote, no hybrids were recognized in the large and complex genus *Coccoloba*. Now many are recognized, including *C. jamaicensis* (*litoralis*), which Sandwith reports resembles *C. boxii*. The genus had not been monographed nor had it received intensive study for about forty years. For the past five years, however, the present writer has been studying the group intensively in the laboratory and in the field and has searched in the area under discussion for the answers to the questions raised by Mr. Sandwith.

It is apparent to me that the two collections cited in the original description of *Coccolobis boxii* coming from one tree represent a single hybrid plant. No collections have been made since then which can be referred to this hybrid species. The parents of the plant upon which this species is based are *C. uvifera* and either *C. swartzii* or *C. swartzii* forma *pubescens*. My feeling is toward the latter, although both *C. swartzii* (*Box 975*) and *C. swartzii* forma *pubescens* (*R. A. & E. S. Howard 11990*) have been collected in the area of Pelican Bay.

Sandwith reported that Box had noted other specimens in the central region of Antigua near Piccadilly and at English Harbour which appear to be conspecific with the plant described. These observations, however, are not supported with voucher specimens and it is my suspicion that Box observed the adventitious shoot leaves of *C. swartzii* forma *pubescens* in these areas. Collections made at Blubber Valley (*R. A. & E. S. Howard 11864* & *11865*) and at Carr's Ghaut (*R. A. & E. S. Howard 11994*) of both adventitious shoots and normal growth show the difference to be expected on one plant. The leaves of the adventitious shoots of *R. A. & E. S. Howard 11994*, in particular, could be included in the concept of *C. boxii* if they had not been collected, personally and carefully, along with the normal foliage from another part of the same plant. The leaves of adventitious shoots of the collection *11864* are slightly more ovate than those of *Box 1497*, but are supported by fruiting branches bearing the small leaves typical of *C. swartzii* forma *pubescens*. A plant collected in sterile condition in Blubber Valley (*R. A. & E. S. Howard 11865*) has on one branch leaves which are a perfect match for *C. boxii* and *C. swartzii* forma *pubescens*.

The specimens collected by Box and the species described by Sandwith are retained as *C. boxii*, although a hybrid status is now recognized for this single plant. Sandwith described the flowers as pistillate and felt that

staminate flowers had fallen. I feel that the Box specimens represent staminate flowers, although only young buds are present and it is difficult to predict the fertility of either pollen or ovule in the stages present. The clusters of flowers are characteristic of functionally staminate plants and the fact that Box was unable to find fruits or fruiting pedicels on the plant in either February or July is indicative of a functionally staminate plant. The striations and general aspect of the branches, the size of the ochrea, the shape of the leaf and its texture and color, as well as the length of the inflorescence, are indicative of parentage involving *C. uvifera* and prevent these collections from assignment to *C. swartzii*.

Coccoloba microstachya Willd. Sp. Pl. 2: 459. 1800; Lindau, Engler Bot. Jahrb. **13**: 146. 1890.

Coccoloba klotzschiana Meisn. DC. Prodr. **14**: 155. 1856; Lindau, Engler Bot. Jahrb. **13**: 148. 1890.

Coccoloba microstachya var. *ovalifolia* Meisn. DC. Prodr. **14**: 162. 1856.

Coccoloba parvifolia Poir. in Lam. Encycl. **6**: 64. 1804.

Coccoloba microstachya var. *rotundifolia* Urban ex Lindau, Engler Bot. Jahrb. **13**: 147. 1890.

Coccoloba microstachya var. *lanceolata* Meisn., DC. Prodr. **14**: 162. 1856.

Coccoloba obtusifolia Lindau, Symb. Antill. **1**: 222. 1899, Britton & Wilson, Sci. Surv. P.R. **5**: 268. 1924, not Jacquin.

Coccoloba punctata Griseb. in part, Flora Brit. W.I. 163, 1859, not Linnaeus.

Shrub or tree to 20 ft. tall; branches terete, the nodes tumid, pubescent or with hair primordia, the bark gray to tan in color; ochrea membranaceous, cylindrical, pubescent, 4 mm. long; petioles 3–6 mm. long, flattened above, normally pubescent; blades variable in size and shape, ovate, ovate-lanceolate, oblong or elliptic, 3.5 × 1.5, 4 × 2, 5.5 × 3.5 to 7 × 4 cm. long and broad, thin-coriaceous, usually turning black on drying, the margin entire, often undulate, sometimes tightly recurved; midrib and veins prominulous on both surfaces, forming a dense reticulum, although blades relatively thick and often somewhat fleshy in fresh condition, the veins 7–9 pairs, prominent or numerous and all equal and less conspicuous, straight or arcuate, curved and anastomosing at the margin; glabrous above, pilose or glabrate below, occasional hairs remaining on the veins or rarely the entire leaf surface persistently pubescent; apex acute, acuminate rounded or emarginate, the base narrowed, rounded or slightly cordate; leaves of adventitious shoots ovate-lanceolate, 10.5 × 5.5 to 16.5 × 5 cm. long and broad on petioles 7 mm. long with ochrea 8 mm. long, the adventitious leaves cordate at the base, generally tapering or acuminate at the apex and often conspicuously puberulent below; inflorescence terminal, 5–10 cm. long, the rachis usually pubescent, tenuous, rarely stout, often geniculate, commonly recurved; staminate flowers two, rarely one or more than two at the nodes; pistillate flowers solitary, the bracts broadly ovate, 0.5 mm. long, puberulent; ochreolae membranaceous, puberulent, to 0.5 mm. long, erect and surrounding the flower in the staminate plants, gen-

erally appressed or flattened against the rachis in the pistillate plants in flower and fruit, pedicels none or shorter than the ochreolae, the hypanthium less than 1 mm. long, the perianth lobes 1–1.5 mm. long and 1 mm. wide; fruit sessile, generally ovate with distinctly coronate perianth lobes, to 6 mm. long and 4 mm. in diameter.

Dominican Republic: Prov. Samana: Samana, *Ekman 15322* (B, S), Cabo Samana, *Ekman 14905* (S). Prov. Puerto Plata: La Boca, *Ekman 14381* (S, US). Arroyo Frances, *Ekman 14400* (S, US), Puerto Plata, *Eggers 2674* (B). Prov. Monte Cristi: El Morro, *R.A. & E.S. Howard 12537* (GH). Prov. unknown: Castillo Maldonado, *Sesse & Mocino 951* (F).

Puerto Rico: Guayanilla: *Britton & Shafer 1817* (F, GH, NY, MO, US); *Sintenis 4868* (MO, US). Guanica: *Britton & Britton 9594* (S); *Sintenis 3707* (B), *3431* (MO, US); *Gregory 181* (NY); *Holdridge 181* (A). Mayaguez: *Heller 4546* (A, B, E, F, GH, NY, Mich, MO, NY, US); *Britton, Cowell & Brown 4359* (NY, US); *Britton & Hess 2715* (F, NY, US). Ponce: *Heller 6128* (A, E, F, GH, MO, NY, US); *Underwood & Griggs 686* (NY, US). Cabo Rojo: *Sintenis 545* (GH, S, US), *Velez 1096* (NY). Cayo Muertos: *Britton, Cowell & Brown 4999* (NY). Punta Guaniquilla: *Britton, Cowell & Brown 4566* (F, GH, NY, US), *4573* (NY, US). Rincon: *Sintenis 5498* (F, NY), *5543* (E, F, NY). Coamo: *Sintenis 3328* (E, GH, S, US). Peñon: *Shafer 1985* (NY, US). Cerro Ventana: *Shafer 2976* (NY, US). Santa Maria to Caballo Colorado: *Shafer 2689* (NY, US). Enseñada Hondo: *Britton & Britton 9645* (NY). Culebra Island: *Britton & Wheeler 8A* (NY, US), *32* (F, NY, US). Mona Island: *Stevens 6170* (NY), *6213* (NY); *Britton, Cowell & Hess 1710* (NY). Vieques Island: *Shafer 2805* (NY, US).

St. Thomas: Bolongo Hill, *Eggers 160* (C, S). Flaghill: *Eggers s.n.* (US). Bordeaux: *Britton & Marble 1378* (C, F, NY, US); *Ostenfeld 328* (C), *330* (C). Without specific location: *Eggers 135* (B), *124* (GH), *714* (A); *Britton, Britton & Shafer 159* (C, F, NY, US); *Paulsen 146b* (NY). Collector not specified: Herb. Kunth, type of *C. klotzschiana.*

St. Jan: Bethania, *Britton & Shafer 192* (NY, US); Solomon's Bay, *Eggers 3314a* (C).

Tortola: *Fishlock 124* (F, NY).

Virgin Gorda: *Fishlock 20* (GH, NY), *279* (GH, US).

Anguilla: *Boldingh 3483b* (NY).

St. Croix: Oxholmia: *Borgesen 64* (C); Fair Plains, *Eggers s.n.* (C); Kingshill *Eggers s.n.* (C); Salt River, *Paulsen 264* (C); Folly Hill, *Raunkiaer s.n.* (C); Rustup Twist, *Mrs. J.J. Ricksecker 365* (F, MO, US); Salt River Cliff, *A.E. Ricksecker 459* (F, GH, MO, NY, US); Christiansted, *Rose Fitch and Russell 3582* (NY, US); Anna's Hope, *Thompson 398* (GH, NY); Mt. Eagle, *Thompson 434* (GH, NY).

A large number of specimens have been seen which were collected by Ryan, Benson, Krebs, Eggers, Swartz, Borgesen and others which lack either locality and are cited as "Ind. Occ." or lack collector's numbers, as well. Little is gained in attempting to cite these specimens which are primarily from the herbaria at Stockholm and Copenhagen. The two specimens in the Willdenow Herbarium in Berlin are *7703*, the type of the species, and *7702*, the type of *C. microstachya* var. *lanceolata* Meisner.

Both are probably from St. Croix and were probably collected by Vahl. Although Lindau listed four Sintenis collections from Puerto Rico, he failed to cite a type when he described *C. microstachya* var. *rotundifolia*.

The holotype of this species is *Willdenow 7703* in the Willdenow Herbarium in Berlin. In his original monograph of this genus, Lindau accepted *Coccoloba microstachya* Willd. and recognized three varieties. *Coccoloba microstachya* var. *ovalifolia* was described earlier by Meisner and included the holotype. *Coccoloba microstachya* var. *lanceolata* was described also by Meisner. Lindau describes a variety *rotundifolia* attributed as a manuscript name by Urban. In the synonymy of *C. microstachya* var. *ovalifolia*, Lindau cites *C. obtusifolia* Jacquin.

In a later treatment of the genus for the West Indies (Symb. Antill. 1: 222. 1899), Urban recognized the earlier publication of the Jacquin name *Coccoloba obtusifolia* and, accepting this as the correct name for the species, listed in synonymy *C. microstachya* and the three varieties recognized in his earlier publication. The rejection of the morphological varieties is based on a better understanding of the variation within this species and particularly within the development of an individual plant. I agree with Lindau's concept of the morphology of the species, but cannot agree with his acceptance of the name *C. obtusifolia* Jacquin. The description and illustration of the plant Jacquin considered *C. obtusifolia* is clearly not the same plant called *C. microstachya* and typified by the Willdenow specimens. Further, *C. obtusifolia* Jacquin is based on a plant from Carthagena in Colombia. This is the plant which Lindau describes as *C. billbergii* (Engl. Bot. Jahrb. 13: 219. 1890) and this species is not known from the West Indies.

Although Willdenow described *Coccoloba microstachya* as having glabrous leaves and stems, the type specimen in the Willdenow herbarium shows a minute but distinct pubescence. In the large number of specimens examined in the herbarium and in the field, the amount and the evidence of the indument varies. The pubescence is often represented only by bases of hairs recognized as clear, lighter colored dots or cells in the epidermis of the dried leaves. Generally a slight pubescence remains on the rachis of the inflorescence and is evident when all other portions of the specimen are glabrous. The extreme in foliar pubescence was seen on a specimen collected by Boldingh (*3483B*) from Anguilla where the lower leaf surface of the mature foliage was almost tomentose.

The variation in leaf shape is great, not only in populations but in individual plants. The three taxa which Lindau recognized in 1890, as he reported later, can be found on a single plant or in a single collection. Within the fourteen sheets of the four Sintenis collections that I have examined, all three varieties can be recognized. Some of the herbarium specimens cited seems to have been selected deliberately in the field to show gross and exaggerated variations. The largest adventitious leaves are on the specimens from St. Croix and many of the collections consist only of such shoots and leaves. However, a Britton & Wheeler collection (*32*) shows both the large leaves of the adventitious shoots as well as the smaller

leaves, presumably of the same plant although no mention is made of this in the field notes. An Ekman collection (*14381*) from Puerto Plata in the Dominican Republic also has fragments from adventitious and normal shoots and the relationship of these is mentioned on the label. An earlier collection by Ekman (*12098*) from La Romana in the Dominican Republic consisted primarily of leaves from adventitious shoots and the annotation that such a plant was "very rare and not seen elsewhere."

Several specimens from St. Croix show an almost teratological thickening of the inflorescence axis. While this is common in other species, and particularly in *Coccoloba swartzii*, it appears unusual in *C. microstachya*.

Coccoloba parvifolia Poir. is based on a Vahl collection and the type is in the Jussieu Herbarium. I have examined a photograph of the type sheet and agree that this species can be referred to the synonymy of *Coccoloba microstachya* Willd. Meisner, however, recognized this species and considered it an "obscure" species from South America. However, the Vahl collection is probably from St. Croix.

The type specimen of *Coccoloba klotzschiana* in the De Candolle Herbarium at Geneva and the fragment of this in the herbarium of the New York Botanical Garden indicate this species may also be referred to *C. microstachya*.

In the extreme forms of *Coccoloba microstachya*, it is difficult to distinguish between this and *C. swartzii*. Usually, however, *C. swartzii* may be recognized by the larger leaves, longer and thicker inflorescence axes, tapered fruit with imbricated perianth lobes, the lack of pubescence (except in forma *pubescens*) and the darker, almost black color of the leaves when dry. By comparison, *C. microstachya* has smaller leaves, tan to brown in color rather than black, exaggerated tumid nodes, shorter and more tenuous inflorescences and fruit with coronate perianth lobes.

Coccoloba pyrifolia Desf. Cat. Hort. Paris ed. 3, 69, 389. 1829.

Coccoloba pirifolia Lindau, Engl. Bot. Jahrb. **13:** 144. 1890, Symb. Antill. **1:** 222. 1899.

Coccolobis pirifolia Lindau, Brit. & Wils. Sci. Surv. P. R. **5:** 267. 1924.

Coccoloba kunthiana Meisner, DC. Prodr. **14:** 166. 1857.

Coccoloba punctata var. *jacquini* Griseb. Fl. Brit. W.I. 163. 1859.

Shrub of 9 ft. to a tree of 30 ft.; trunk to 14 inches diameter at breast height; branches striate, glabrous, the nodes not conspicuously swollen; ochrea subcoriaceous, glabrous, shriveling rather than deciduous, 1 cm. long; petioles inserted below the ochrea, glabrous, 0.6–1.5 cm. long; blade ovate-lanceolate, broadly ovate or occasionally completely orbicular, 4.5 × 2.5, 9 × 5, 12 × 6, cm. long and broad, coriaceous, glabrous, opaque to almost shining, the margin entire, sometimes recurved, the midrib slightly evident below, prominent above, the primary veins flat, slightly impressed above, very slightly evident below, the secondary venation obscure, the apex obtuse, acute or rarely acuminate, the base rounded, narrowed or subcuneate; inflorescence terminal, spike-like, 1–2 times the length of the

leaf or terminal on lateral shoots, 8 to 31 cm. long, glabrous, the staminate and pistillate flowers borne singly, the bracts triangular to 1.5 mm. long, the ochreolae membranaceous, equalling the bracts; pedicels wanting; hypanthium 1 mm. long, the perianth lobes ovate, to 2 mm. long, the filaments of fertile stamens 3 mm. long; fertile pistil to 2.5 mm. long; fruit globose, ca. 4 mm. in diameter, rounded at the base, obscurely 3-angled, the perianth lobes coronate, laxly acuminate; achene tan in color.

Puerto Rico: MAYAGUEZ: *Cowell 730* (F, US), *731* (F, NY, US); *Otero & Alvarez 540* (A, F); *Sintenis 1018* (BM, US); *Heller 4560* (A, E, F, GH, Mich., MO, NY, US). SIERRA DE LUQUILLO: *Sintenis 1405* (F, MO, S), *1501* (BM, GH, NY, US); *Britton & Bruner 7551* (NY). SANTURCE: *Heller 614* (F, NY, US), *1259* (F, NY), *1268* (NY, US). LA ESTANCITA: *Eggers 1173* (US). MT. ALEGRILLO: *Britton, Stevens & Hess 2572* (F, MO, NY, US); *Sintenis 238* (GH, MO, S, US); *Hess 645* (NY). VEGA ALTA: *Britton, Britton & Brown 6796* (F, NY, LECTOTYPE, US). CAMUY: *F.H. Sargent B-200* (US). GUAYAMO: *Britton, Britton & Brown 6544* (F, NY, US). MARTIN PENA: *J.R. Johnston 1867* (NY, US). MT. MORALES: *Britton & Marble 1058* (NY, US). MARICAO: *F.H. Sargent 397* (US). BAYAMON: *Sintenis 990* (BM, GH, US); *Britton, Britton & Boynton 8455* (GH, NY, US). LAGO SAN JOSE: *Hioram 372* (NY). VEGA BAJA: *Stevens 1932* (NY). YAUCO: Indiera Baja, *Britton & Britton 7227* (NY). CAYEY: *Otero 730* (A, NY). ESPINOSA above Toa Baja: *Britton & Britton 9709* (NY). SAN JUAN: *Gerhart & Holdridge 536* (NY). CATANO: *Britton, Britton & Brown 6980* (NY). SIERRA DE NAGUABO: *Shafer* 3480 (NY). TORO NEGRO, Doña Juana: *Gregory 54* (NY).

Coccoloba pyrifolia Desfontaines was described in the third edition of the catalogue of plants in the botanic garden at Paris and was based on material under cultivation there. The origin of the plant is given as the warmer Antilles. No holotype exists for this species and no lectotype has been selected, to the best of my knowledge. There is in the herbarium at Geneva a specimen without collector's name or date, bearing a label indicating its origin as "hort. paris." It is possible that this specimen represents the original material cultivated and described in 1829 and could possibly be considered as the type. It seems more desirable to select a new lectotype from more recent collections and so *Britton, Britton & Brown 6796* is designated the type collection, with the holotype at the New York Botanic Garden herbarium. The species has been reported from Puerto Rico, St. Thomas, Cuba and Jamaica. I have seen the collections which Lindau cited from the herbaria at Berlin and Göttingen and there are currently no collections from St. Thomas. Lindau's reference to the occurrence of this species on St. Thomas cannot be checked. Likewise the Wilson specimen from Jamaica which Lindau states is in the Grisebach Herbarium cannot be located. Fawcett & Rendle repeat this reference which cannot be verified. The two collections by Charles Wright from Cuba which Sauvalle refers to this species in his Flora Cubana (139. 1873) are *Wright 2253* which is *Coccoloba praecox* Wright ex Lindau and *Wright 2256* which is the type of *C. reflexa* Lindau. It appears that *C.pyrifolia* is currently limited to Puerto Rico. The original spelling of the specific

name is retained in this treatment, although all recent authors have preferred to use *Coccoloba pirifolia*.

Meisner's original description of *Coccoloba kunthiana* contains few diagnostic characters and is clearly referable to the synonymy of this species. I have seen specimens in the De Candolle Herbarium on which Meisner's species is based and conclude the differences recognized by various authors in the past have been primarily of growth characters. The plants with older and shorter compacted branches are named *C. kunthiana* and are similar to Meisner's type. These specimens also have smaller ovate leaves which are generally obtuse at the apex. Specimens from obviously faster growing shoots have larger leaves which are acute or acuminate at the apex and possess longer inflorescences. These specimens, almost without exception, have been referred to *C. pyrifolia*. It is quite clear from a study of the material cited and from a field knowledge of the species that only a single taxon is represented and that the larger acute leaves are produced on adventitious or vigorously growing shoots.

Coccoloba pyrifolia is easily recognized by the long thin inflorescences with sessile flowers. It is most easily distinguished from *C. swartzii* by having leaves which dry dark brown and almost shiny above and light brown or tan beneath and which have very inconspicuous venation.

Coccoloba krugii Lindau, Engl. Bot. Jahrb. 13: 145. 1890, Symb. Antill. 1: 222. 1899.

Coccoloba børgesenii Schmidt, Fedde Repert. Sp. Nov. **24**: 75. 1927.

Coccoloba børgesenii forma *ovato-lanceolata* Schmidt, Fedde Repert. Sp. Nov. **24**: 76. 1927.

Shrub or small tree to 6 m. tall; branches terete, glabrous, slightly geniculate and nodose; ochrea membranaceous, persistent, 3–5 mm. long; petioles borne at the base of the ochrea, corky at the base, 5–6 mm. long; blade ovate to suborbicular 2 × 1.8, 4 × 3.5, 5 × 4 cm. long and broad, thin-coriaceous, glabrous or rarely with a few hairs near the attachment of the petiole, the margin flat or recurved, the midrib flat above slightly prominent below, the primary veins 4–6 pairs, straight, bifurcating and anastomosing near the margin, flat on both surfaces, the secondary venation minutely reticulate below, smooth above, the apex obtuse or rounded, the base cordate or rounded; adventitious leaves from the base of the ochrea 1 cm. long with petioles 1 cm. long and blades cordate or elliptic to 7 × 6 cm. long and broad; inflorescence terminal, 5–8 cm. long, rachis glabrous, the staminate flowers 1–3 per node, the pistillate flowers borne singly, the bracts broadly ovate, membranaceous, 1 mm. long; ochreolae membranaceous, flaring to 1 mm. long; pedicels wanting or shorter than the ochreolae, the hypanthium 1 mm. long, the perianth lobes ovate, to 2 mm. long, the filaments of fertile stamens 1.5 mm. long; fruit ovoid or angularly fusiform, strongly triangular in outline, 4–5 mm. long, 3–3.5 mm. in diameter, the perianth lobes appressed, above half the length of the fruit.

Local names: Cragwood (Bahamas); Wild Grape (Virgin Islands).

Bahamas: ACKLIN'S ISLAND: *Eggers 3960* (B, US); *Brace 4387* (FM, NY, US), *4495* (FM, NY). ANDROS: *Brace 5235* (FM). CAICOS ISLANDS: S. Caicos, *Wilson 7594* (FM, G, NY); W. Caicos, *Wilson 7754* (MF, G, NY); Dellis' Cay, *Millspaugh 9225* (FM, G, NY). CAT. ISLAND: Fort Hine, *Britton & Millspaugh 5948* (FM, NY); The Bight, *Britton & Millspaugh 5917* (FM, NY); Orange Creek, *Britton & Millspaugh 5779* (FM, NY); Port Hower, *Hitchcock s.n.* (MO). CROOKED ISLAND: *Brace 4748* (FM, NY); *Hitchcock s.n.* (FM, G, NY). FORTUNE ISLAND: *Eggers 3801* (US), *3998* (US); *Rothrock 261* (FM, G, NY). INAGUA: *Nash & Taylor 1059* (FM, NY), *968* (FM, NY); *Hitchcock s.n.* (MO). LONG CAY: *Brace 4040* (FM, NY, US). NEW PROVIDENCE: *Britton & Brace 361* (FM, NY), *363* (FM, NY, US), *364* (FM, NY), *372* (FM, NY), *375* (FM, NY); *Curtis 71* (A, FM, G, MO, NY, US). WATLING'S ISLAND: *Britton & Millspaugh 5194* (NY); *Coker 473* (NY); *Wilson 7215* (FM, G, MO, NY), *7324* (FM, G, MO, NY).

Haiti: Tortue, Morne Barranca, *Ekman 4314* (TYPE of *C. børgesenii*, S, US); Port au Paix, Valle des Trois Rivieres, *Ekman 3588* (TYPE of *C. børgesenii* forma *ovato-lanceolata*, S, US); Port au Paix, *E.C. & G.M. Leonard 15252* (A, G, US).

Dominican Republic: Prov. Monte Cristi: El Morro, *Ekman 13143* (S), *R.A. & E.S. Howard 12532* (G), *12534* (G).

Jamaica: St. ANDREW: Long Mt. on road to Wareka, *Harris 10008* (FM, NY, US), *10014* (FM, NY, US), *Maxon 10521* (G, NY, S, US), Long Mt., *Howard 12033* (G). St. CATHERINE: Great Goat Island, *Harris 9335* (A, FM, NY, US). St. ELIZABETH: Lovers Leap, Santa Cruz Mts., *Britton 1149* (NY). St. THOMAS: Albion Mt., *Harris 11680* (FM, G, MO, NY, US), *11681* (FM, G, MO, NY, US). TRELAWNEY: Ramgoat Cave, *Howard & Proctor 14392* (A), *Howard, Proctor & Stearn 14683* (A).

Puerto Rico: Guanica near Salinas, *Britton, Britton & Boynton 8314* (NY); Guanica in woods on Monte Cobana, *Sintenis 3776* (MO, NY); *Ponce, Underwood & Griggs 673* (NY, US); *Heller 6211* (A, FM, GH, MO, NY, US); *Britton & Cowell 1289* (NY, US); Icacos Cay, *Britton 7153* (NY); Vieques Island, *Shafer 2785* (NY, S, US); Guayanilla, *Britton & Shafer 1841* (F, MO, NY, US).

Anagada: *Fishlock 26* (NY), *27* (NY); *Britton & Fishlock 1001* (NY), *1063* (F, NY, MO, US), *J. Beard 323* (A).

Antigua: Frecetown, *Box 845* (US); Goble Creek near Gaynors, *Box 1388* (US).

Barbuda: *Fairchild 3829* (A, US).

St. Martin: *Boldingh 2756B* (NY).

There is little reason to confuse *Coccoloba krugii* and *C. swartzii*, although such errors of identification are relatively common on herbarium sheets. The smaller rounded leaves, light in color with short, pale gray petioles, distinguish *C. krugii* in sterile and flowering condition. The smaller and distinctly triangular fruits of *C. krugii* are equally characteristic.

Coccoloba børgesenii was described by Schmidt as having a puberulent inflorescence rachis. This "puberulence" on the type specimen appears to be a mixture of fungal hyphae, crystals of mercuric bichloride and fibers from the pressing material. The type specimen of *C. børgesenii* forma *ovato-lanceolata* consists of a vigorously growing shoot with larger leaves

than the species and again represents the difference between adventitious shoots and normal growth.

All of the characters Schmidt uses to separate this species and its form are expected variations present in *Coccoloba krugii*.

Lindau based the original description of *Coccoloba krugii* on two collections of Sintenis (*3497*, *3776*) from Puerto Rico and two collections of Eggers from Fortune and Acklins Island (*3801*, *3960*). No holotype has been selected and a lectotype should be designated. The Sintenis collection 3497 in the Berlin Herbarium should be so considered. In recent years *C. krugii* has been collected on additional islands of the Bahamas, on Jamaica, Haiti and the Dominican Republic, several islands of the Virgin Island group and Antigua of the Leeward Islands.

Coccoloba leonardii Howard, Jour. Arnold Arb. 30: 419. 1949.

This species was based on a specimen collected by E. C. and G. M. Leonard on Tortue Island, Haiti. In the original publication additional material was cited from Haiti proper, Navassa Island and Cuba. I have not seen any additional material in recent collections which can be referred to this species.

Coccoloba leonardii is closely related to the polymorphic *C. swartzii*, but is readily distinguishable in fruiting condition by having fusiform, bicolorous fruits which are larger than those of *C. swartzii* from the Greater Antilles. The flowering spikes of *C. leonardii* appear more tenuous and often tortuous in comparison with the majority of specimens of *C. swartzii* and the striking asymmetry of the leaf base combined with a characteristic ashen color of the dried leaves appears to distinguish this species in sterile condition, as well.

A MONOGRAPHIC STUDY OF THE WEST INDIAN SPECIES OF PHYLLANTHUS *

GRADY L. WEBSTER

With two plates

SYSTEMATIC TREATMENT

IN THE FOLLOWING PAGES are treated all of the species of *Phyllanthus*, whether spontaneous or cultivated, which have been observed in the West Indies. For the purposes of this study the West Indian region is defined as the area bounded by (and including) Bermuda and the Bahamas on the north, Swan Island and the Providenciales on the west, and Curaçao, Trinidad, and Tobago on the south; the Florida Keys, as well as Margarita and the smaller islands off the Venezuelan coast, are therefore excluded. The inclusion (for reasons of convenience) of Trinidad, which has a predominantly South American flora, results in the mustering in of two species which are otherwise South American; but by and large the species here included represent a strikingly self-contained assemblage for such a large and diverse area, encompassing as it does a broad range of latitude and great diversity of climates, geological formations, and vegetational zones.

One of the most troublesome problems which faces anyone who wishes to investigate a West Indian *Phyllanthus* is that of deciding if the plant at hand actually belongs to the genus. The following purely artificial key to the West Indian representatives of Phyllantheae is therefore presented with the aim of facilitating determination. It should be noted that the tribe Phyllantheae is here circumscribed in a narrow sense, comprising the subtribe Phyllanthinae and part of the Andrachninae of Pax (Natürl. Pflanzenfam. ed. 1, 3(5): 14. 1890), or the subtribes Glochidiinae, Phyllanthinae, Andrachninae, and Wielandiinae of Pax and Hoffmann (Natürl. Pflanzenfam. ed. 2, 19c: 32–33. 1931). It is evident that further research will result in interpretations of the tribes and subtribes radically different from the arrangement of Pax and Hoffmann.

ARTIFICIAL KEY TO WEST INDIAN GENERA OF PHYLLANTHEAE

A. Plants in flower

1. Branching phyllanthoid ..... **Phyllanthus**
1. Branching not phyllanthoid.
   2. Petals present, at least in male flower; stamens 5.
      3. Monoecious subshrub, microphyllous, the leaves only 1–2 mm. long ..... **Andrachne**
      3. Dioecious shrubs or trees with much larger leaves.
         4. Petals about as large as the calyx-lobes; pistillode peltate; petiole c. 2 cm. long or more ..... **Astrocasia**

* Continued from volume XXXVII, page 268.

4. Petals much smaller than calyx-lobes; pistillode slender, usually lobed; petioles much shorter ..... **Savia**

2. Petals absent.
3. Pistillode present, stamens 5; dioecious shrubs or trees.
4. Male flowers subsessile, glomerate; leaves chartaceous, triplinerved, narrowly peltate ..... **Chascotheca**
4. Male flowers pedicellate; leaves coriaceous, pinnately nerved, never peltate ..... **Securinega**
3. Pistillode absent.
4. Stamens 4; floral disk annular; dioecious tree ..... **Margaritaria**
4. Stamens 3; floral disk not annular; monoecious or dioecious herbs or shrubs ..... **Phyllanthus**

B. Plants in fruit

1. Branching phyllanthoid ..... **Phyllanthus**
1. Branching not phyllanthoid.
2. Petioles 2 cm. long or more; fruiting pedicels 4 cm. long or more, the calyx-lobes deciduous from the massive receptacle ..... **Astrocasia**
2. Petioles, and usually fruiting pedicels, much shorter.
3. Leaves only 1–2 mm. long ..... **Andrachne**
3. Leaves larger.
4. Branches glabrous.
5. Fruit not separating regularly into cocci; seed-coat fleshy without, bony within, the hilum deeply excavated **Margaritaria**
5. Fruit regularly dehiscent into 3 cocci; seed coat neither fleshy nor bony, the hilum not excavated.
6. Seed bullate-rugose, the hilum abaxial ..... **Chascotheca**
6. Seed otherwise.
7. Leaves coriaceous and narrowly spathulate, or else branches ending in spines ..... **Securinega**
7. Leaves otherwise; branches never spiny.
8. Herbs or subshrubs, or if shrubby (*P. botryanthus*) then fruits borne on "naked" thyrses ... **Phyllanthus**
8. Trees; fruit axillary to foliage leaves ..... **Savia**
4. Branches pubescent.
5. Branches hirtellous with spreading hairs ..... **Phyllanthus**
5. Branches sericeous-pilose with appressed hairs ..... **Savia**

Once a doubtful specimen has been assigned to *Phyllanthus*, the task of determining it to species may still appear rather formidable. The first step should always be to decide whether or not the branching is phyllanthoid (cf. Jour. Arnold Arb. 37: 104 et seq. 1956). Since the sex and number of flowers produced per node is often an important character, it should be kept in mind that this can often be determined even from a branch that has lost most of its flowers; the number of pairs of persistent bracteoles usually give a good indication of the number of flowers, and the stumps or scars of the female flower pedicels are usually distinctly larger in diameter than those of males.

Flower-parts should be measured in water at a magnification of 15 to 50 diameters if exact correspondence with the descriptions is desired. How-

ever, in practice measurements taken from dried organs on the herbarium specimen are often accurate enough. It should be kept in mind, however, that the measurements apply in most cases to fully mature organs. Since some structures, particularly staminal and stylar columns, may undergo great elongation at anthesis, due allowance must be made for measurements taken from the bud.

The height of the staminal column, when there is more than a single whorl of anthers, is measured from the base to the attachment of the upper whorl of anthers. The length and breadth of the anthers are given in relation to their morphologically longitudinal axes. As discussed in the section on floral morphology, the direction of dehiscence of the anther is expressed topographically, i.e., in relation to the long axis of the entire flower rather than of the individual stamen.

Because of the diverse stylar configurations in the genus, it is difficult to express the dimensions in consistent terms. If the styles are erect and united, the height of the stylar column is given. If they are free and spreading, the length given in the descriptions refers to the purely topographical extent to which they can be straightened out when moistened. The degree of division of the style, on the other hand, refers to its total length and takes into account any twists which cannot be uncoiled.

The size, shape, and ornamentation of the seeds furnish excellent characters for purposes of identification. The stated dimensions are understood to apply in relation to the longitudinal (vertical) axis of the seed as it sits in the capsule. Thus the radial dimension is measured along either of the lateral faces or on the flat face if one of them is carinate, while the tangential is the width of the seed when lying on its back. Since the capsules of many species tend to dehisce — even if immature — when the specimen is dried, immature seeds may often be found mixed with the mature ones. This makes it difficult to determine the actual range in seed size, particularly since in some species the two seeds of a locule are normally unequal in size. Usually, however, one can distinguish well-developed seeds by their plumpness, more well-defined ornamentation, and less shiny surface.

The specimens cited in this work have been made available through the courtesy of the curators of the following institutions[1]: Arnold Arboretum (A); Botanisches Museum, Berlin-Dahlem (B); British Museum (Natural History), London (BM); Jardin botanique de l'Etat, Brussels (BR); Botanical Museum and Herbarium, Copenhagen (C); Chicago Natural History Museum (F); Conservatoire et Jardin botaniques, Geneva (G); Gray Herbarium (GH); Systematisch-Geobotanisches Institut, Universität Goettingen (GOET); Science Museum, Institute of Jamaica, Kingston (JAM); Herbarium, Royal Botanic Gardens, Kew (K); Rijksherbarium, Leyden (L); Herbario de la Salle, Vedado, Habana (LS); University Herbarium, University of Michigan, Ann Arbor (MICH); Missouri Botanical Garden, St. Louis (MO); Herbier Marie-Victorin, Institut

[1] Herbarium abbreviations are the standard ones of Lanjouw and Stafleu, Index Herbariorum ed. 2 (1954), except for the Science Museum, Institute of Jamaica, which is unlisted.

Botanique, Université de Montreal (MT); New York Botanical Gardens (NY); Museum National d'Histoire Naturelle, Laboratoire de Phanérogamie, Paris (P); Naturhistoriska Riksmuseum, Stockholm (S); Herbarium, Estación Agronómica de Cuba, Santiago de las Vegas, Habana (including Herbarium of Juan Roig) (SV); Herbarium, Imperial College of Agriculture, Port of Spain (TRIN); United States National Museum, Department of Botany, Washington (US); Naturhistorisches Museum, Vienna (W).

Phyllanthus L. Sp. Pl. 981. 1753.

Niruri Adans. Fam. Pl. **2**: 356. 1763.
Urinaria Medic. Malvenfam. 80. 1787.
Diasperus O. Ktze. Rev. Gen. **2**: 596. 1891.

Trees, shrubs, or herbs of very diverse habit. Branching either unspecialized — the phyllotaxy spiral or distichous — , or phyllanthoid, i.e., the spiralled leaves on main axes reduced to cataphylls which subtend deciduous branchlets with distichous leaves. Leaves varying greatly in size and texture but always entire, and glabrous in most species; petiole always much shorter than the blade; stipules deciduous or persistent, often indurate. Plants monoecious or subdioecious, rarely dioecious; inflorescences axillary (sometimes pseudoterminal), or more or less greatly reduced cymes, these aggregated into thyrses in some species; the individual flowers bibracteolate. Flowers apetalous; calyx gamophyllous, 4–6-lobed, the lobes imbricate in the bud (decussate in calyces with 4 lobes); disk nearly always present in the flowers of both sexes. Male flower pedicellate; stamens 2–15, mostly 3–6; filaments free or connate; anthers free or connate, almost invariably extrorse; disk usually divided into segments alternating with the calyx-lobes, less commonly undivided; pistillode absent; pollen grains oblong to globose, with various ornamentation patterns, small (c. 15–35 μ in diameter). Female flower pedicellate or subsessile; calyx-lobes 5 or 6 (rarely 4), entire or less commonly toothed or lacerate; disk various: cupuliform or plane, entire or lobed or divided into segments, absent in a few species; staminodia absent (except in *P. acidus*); ovary usually of 3 carpels, in a few species of 4 up to 12 (only 2 in *P. chacoensis*), smooth or less commonly roughened, bullate, or hairy; ovules always two in each locule, usually collateral (at least at first), anatropous or amphitropous, with two integuments; nucellus usually projecting beyond exostome as a beak in contact with the obturator; embryo-sac the normal 8-nucleate type; styles erect or spreading, free or united into a column, bifid, multifid, or dilated into an entire or lacerate stigma. Fruit mostly a dehiscent capsule (the cocci explosively dehiscent in many species), less commonly baccate or drupaceous, the carpels normally separating as crustaceous cocci from a persistent columella. Seeds usually two in each locule, sometimes unequal, rarely only one developing to maturity; seed-coat dry, crustaceous, smooth or variously ornamented; endosperm whitish, cartilaginous; embryo straight or slightly curved, the cotyledons usually considerably broader than the radicle.

TYPE SPECIES: *Phyllanthus niruri* L.

As delimited in this work, *Phyllanthus* is primarily an Old World genus, only about 200 of the 650 species being native to the New World. The West Indian region, however, harbors a disproportionately high percentage of the native American species; in the western hemisphere only southern Brazil appears to be a comparably important center of speciation.

A detailed analysis of the generic relationships of *Phyllanthus* is beyond the scope of the present treatment. Here it must suffice to say that of the other West Indian genera of Phyllantheae, a close affinity is shown only by *Margaritaria*, which is well distinguished by its very different fruit structure. Still more closely related but evidently generically distinct are a series of Old World genera with phyllanthoid branching: *Glochidion*, *Breynia*, *Sauropus*, and *Phyllanthodendron*.

The generic limits of *Phyllanthus*, as here interpreted, correspond rather closely to those earlier held by Pax (Natürl. Pflanzenfam. ed. 1, 3(5): 18–23. 1890), with the exception that *Margaritaria* is here recognized as a distinct genus. The subgeneric divisions, on the other hand, are very different from those in the interpretations of Mueller and of Pax. The most radical innovations are the grouping of the sections into subgenera and the breaking up of the Muellerian sect. *Euphyllanthus* into a number of small sections, some of which belong to different subgenera. These changes in concept, which are now undertaken only after study of representatives of all sections of the genus (whether West Indian or not), are due largely to the application of new criteria — in particular, the branching and pollen types. Since, however, examination of the small pollen grains of *Phyllanthus* is very inconvenient for making routine identifications, the reader may prefer to use the artificial key to the subgeneric groups (Appendix I).

SYNOPSIS OF THE SUBGENERA [2]

1. Branching not phyllanthoid; herbs or subshrubs with spiral or distichous leaves; stamens 3, filaments (in ours) free; pollen grains (in ours) colporate. . . . . I. **Isocladus**

1. Branching phyllanthoid, or if not then plants shrubby and filaments connate.
   2. Pollen grains colporate, striate, or foveolate; [3] woody or herbaceous, branching phyllanthoid; stamens 2–5, filaments free or connate; fruit various.
      3. Stamens 5; pollen grains colporate; carpels 3–10 . . . . II. **Kirganelia** [4]
      3. Stamens 2–4.
         4. Trees with drupaceous or pithy fruits; carpels 3 or 4; pollen grains colporate . . . . . III. **Cicca** [5]
         4. Herbs or low shrubs with capsular fruits; carpels 3; pollen grains colporate, striate, or foveolate . . . . . IV. **Phyllanthus**

[2] The keys and descriptions are in most cases based solely on West Indian material, and do not take into account exceptional species outside our limits.

[3] Apparently acolpate in an anomalous species of subg. *Phyllanthus*.

[4] Subgenus **Kirganelia** (Juss.), stat. nov. *Kirganelia* Juss. Gen. Pl. 387. 1789.

[5] Subgenus **Cicca** (L.), stat. nov. *Cicca* L. Mant. 17. 1767.

2. Pollen grains otherwise; entirely woody; stamens 2–15, filaments usually connate; fruit capsular, dry or rarely somewhat fleshy.
   3. Pollen grains porate; perianth segments lacerate; stamens 2 ..... V. **Eriococcus**
   3. Pollen grains not porate; perianth segments not lacerate.
      4. Pollen grains echinulose, with short colpi; stamens 3; branching phyllanthoid, branchlets bipinnatiform ..... VI. **Conami**[6]
      4. Pollen grains areolate.
         5. Branching not phyllanthoid; stamens 3 .... VII. **Botryanthus**[7]
         5. Branching phyllanthoid; stamens 2–15 .... VIII. **Xylophylla**

Subgenus I. **Isocladus,** subg. nov.[8]

Herbs or shrubs with unspecialized branching, the leaves spirally or distichously arranged. Monoecious or dioecious. Male flower: calyx-lobes 5; disk-segments 5; stamens 3, the filaments free or united, anthers dehiscing vertically or horizontally; pollen grains colporate or areolate with ora midway between the angles. Female flower: calyx-lobes 5; disk cupuliform or of 5 segments, the segments often bifid; ovary 3-celled, styles free or united. Fruit a dehiscent capsule; seeds trigonous, smooth or verruculose.

This subgenus is typified by sect. *Paraphyllanthus*,[9] which does not occur in the West Indies; our representatives all belong to sect. *Loxopodium*. Subgenus *Isocladus* includes the species which vegetatively appear to be the least specialized within the genus. The species of sect. *Paraphyllanthus*, in particular, are similar in aspect to some species of *Andrachne*; but the male flower is so different in the two groups that a direct relationship appears unlikely.

In addition to sects. *Paraphyllanthus* and *Loxopodium*, subg. *Isocladus* also includes sects. *Macraea* and *Anisolobium*, these last being primarily Old World groups. The subgenus as a whole is thus circumtropical in distribution and comprises about 60 species of diverse habit.

[6] Subgenus **Conami** (Aubl.), stat. nov. *Conami* Aubl. Hist. Pl. Guian. Fr. 926–927, *pl. 354*. 1775.

[7] Subgenus **Botryanthus, subg. nov.** Frutices vel arbores monoicae ramulis distichis, glabris vel hirsutulis, foliis nonnihil magnis; floribus axillaribus vel in thyrsis; flore masculo laciniis calycis plerumque 6, staminibus 3, filamentis connatis, antheris plusminusve horizontaliter dehiscentibus, granis pollinis globosis, areolatis; flore femineo laciiniis calycis 6, disco integro vel crenato, ovario loculis 3, stylis erectis, connatis, ad apicem reflexis; capsula sicca, seminibus laevibus. — Species typica *Phyllanthus grandifolius* L.

[8] Subgenus **Isocladus,** subg. nov. Herbae fruticesve, ramificatione disticha vel spirale; flore masculo staminibus 3, filamentis liberis vel connatis, granis, pollinis oblongis vel globosis, sulcatis vel areolatis; flore femineo disco integro vel dissecto, ovario laeve loculis 3, stylis bifidis; capsula in coccis 3 dehiscentia; seminibus trigonis verruculosis vel laevibus. — Species typica *Phyllanthus maderaspatensis* L.

[9] The type of sect. *Paraphyllanthus* (Muell. Arg. Linnaea **32**: 3. 1863; DC. Prodr. **15**(2): 355. 1866) is hereby designated as *P. maderaspatensis* L.; and the section is redefined so as to exclude all species with phyllanthoid branching, such as *P. urinaria* L.

Sect. 1. **Loxopodium** Webster, Contr. Gray Herb. 176: 46. 1955.

Geminaria Raf. Western Minerva 42. 1821.
Synexemia Raf. Neogenyton 2. 1825.

Annual or perennial herbs, sometimes suffruticose; primary axis or axes erect, bearing distichous leaves and axillary flowers; branches terete, compressed, or winged. Stipules acuminate, more or less auriculate or appearing peltate at the base, entire or denticulate. Leaf-blade membranous or chartaceous, not over 3 cm. long.

Monoecious, subdioecious, or dioecious, the flowers present on all orders of branching in contracted unisexual or bisexual cymes. Male flower: pedicel slender, articulate near the middle; calyx-lobes 5 or 6; disk of 5 or 6 distinct segments; stamens 3, filaments free or rarely connate at base; anthers subglobose or flattened, the connective enlarged adaxially; anther-sacs opening horizontally; pollen grains oblong, 4-colporate, the ora transversely elongate, reticulation obscure. Female flower: pedicel straight at anthesis, becoming geniculate-reflexed in fruit, usually 1 mm. long or less; calyx-lobes 5 or 6; disk cupuliform, lobed, or parted into 5 or 6 segments; ovary smooth; styles free or somewhat fused basally, usually bifid. Capsule green or reddish, not strongly nerved; seeds trigonous, brown to fuscous, not over c. 1.7 mm. long, verruculose or smooth.

Type species: *P. caroliniensis* Walt.

This strictly New World group of perhaps a half dozen species (and a number of subspecies) is well defined by the completely distichous phyllotaxy, flowers on all orders of branching, and colporate pollen grains. Some of the species of the Old World sect. *Macraea* are very similar to the West Indian plants both in aspect and in floral morphology, but they have very different areolate pollen grains. A very close similarity in many details is also shown by the species of sect. *Urinaria*, which however have phyllanthoid branching. Members of sect. *Loxopodium* are as a rule small and inconspicuous plants; they tend to be mesophytes growing in wet savannas and along stream-beds, but some varieties of *P. caroliniensis* are found on dry limestone areas.

KEY TO THE SPECIES

1. Capsule 2 mm. or less in diameter, the seed 0.7–1 mm. long; stem and branches terete or flattened, not winged; strictly monoecious, the cymules bisexual. ..... 1. *P. caroliniensis*
1. Capsule about 3 mm. in diameter, the seed 1.3–1.7 mm. long; stems and branches flattened, sharply angled or winged; male and female flowers at separate axils.
   2. Seed smooth; capsule olivaceous; annual with subsimple stems; styles appressed, horizontal. ..... 2. *P. hyssopifolioides*
   2. Seed verruculose; capsule reddish; perennial with stems clustered on a caudex; styles erect-ascending. ..... 3. *P. heliotropus*

1. **Phyllanthus caroliniensis** Walt. Fl. Car. 228. 1788.

Diasperus carolinensis (Walt.) O. Ktze. Rev. Gen. 2: 598. 1891.

Annual or short-lived perennial herbs, usually erect, mostly 1–3 dm. high, the base never becoming more than softly woody; taproot usually simple, with filiform lateral roots. Primary stem straight with pinnately arranged branches (branches of tertiary order sometimes developing), or replaced above by few to several erect secondary branches. Branches terete or somewhat flattened, never winged (in West Indian forms), greenish, brownish, or reddish-tinged, smooth or papillate-scabridulous, the internodes quite variable in length (2–15 mm.). Stipules ovate-triangular to lanceolate, acute or more often acuminate, usually more or less auriculate at the base, nearly entire to conspicuously dentate, thin and papery or becoming slightly toughened, pale brown or reddish-brown, 0.7–2 mm. long, 0.4–0.6 mm. broad. Petioles smooth, 0.5–1 mm. long. Leaf-blades obovate, elliptic, or oblong, obtuse or rounded and apiculate (rarely sharply acute), acute at the base, c. 5–20 mm. long, 2–10 mm. broad, membranous to rather firm; above bright green or olivaceous, usually smooth, the nerves only slightly raised; beneath green, pruinose, or rubescent, smooth to papillate, midrib prominently raised, lateral veins often somewhat raised, tertiary veinlets anastomosing to form a delicate reticulum, or not visible; margin scarcely to conspicuously thickened, smooth or scabridulous.

Monoecious, all axils except the lowest on the primary stem normally floriferous; cymules axillary, greatly reduced: male flowers 1 or 2, followed by 1 or 2 (rarely 3) female flowers.

Male flower: pedicel c. 0.6–1 mm. long. Calyx-lobes (5) 6, oblong to suborbicular, rounded or obtuse, more or less entire, 0.5–0.7 mm. long, 0.5–0.8 mm. broad, thin and scarious, pale yellowish (rarely pink-tinged), 1-nerved. Disk of (5) 6 elliptic to broadly cuneate entire or crenulate segments. Stamens 3, filaments free, obliquely ascending; anthers emarginate, anther-sacs parallel, inserted on the adaxially broadened connective, opening horizontally, not confluent.

Female flower: pedicel sharply reflexed, usually geniculate, smooth, terete, often reddish-tinged, 1 mm. long or shorter. Calyx-lobes 6 (rarely 5 or 7), linear-oblanceolate to oblong, rounded to acute, 0.6–1.4 mm. long, with a narrow to broad whitish or yellowish often reddish margin and a thicker convex herbaceous midrib area, red-tinged at the base or sometimes entirely reddish, 1-nerved, the midrib plane without, saliently raised within. Disk entire or lobed or dissected into roundish or cuneate segments, rather thin, not glandular. Ovary smooth; styles free and sharply ascending or somewhat fused at the base and more or less horizontally spreading, not over c. 0.3 mm. long, bifid (sometimes shallowly so), the arms slender or thickened, spreading apart or recurved, rounded or subcapitate at the tip.

Capsule c. 1.6–2 mm. in diameter when mature but often precociously dehiscent; valves thin, smooth, olivaceous or reddish-tinged, nervation obscure. Seeds 0.7–1 mm. long, 0.6–0.75 mm. radially and tangentially,

usually dull greyish-brown when mature, verruculose, i.e., covered with evenly or rather irregularly spaced dark raised points.

This is the most widespread and — with the possible exception of *P. niruri* — most variable of the New World species of *Phyllanthus*. It occurs from Illinois and Pennsylvania south throughout most of tropical America to Argentina and Paraguay, although in parts of this range it may be an introduced weed, and has also colonized the Galapagos Islands. Its true limits have not been understood owing to the rather confused treatment by Mueller Argoviensis in the "Prodromus" (1866), where the different populations are distributed among no less than four different species: *P. pruinosus*, *P. schomburgkianus*, *P. caroliniensis*, and *P. stenopterus*, these last two placed considerably distant from the first two. Although the systematic elaboration of *P. caroliniensis* will itself require a special monograph, it is already evident that the species includes some distinctive subordinate taxa with well-defined ranges. In the West Indies these are three:

KEY TO THE WEST INDIAN SUBSPECIES

1. Branches scabridulous with papillae scattered or in striae; disk of female flower lobed or parted into segments; calyx-lobes of female flower broadly oblong or spathulate, usually rounded or obtuse, often reddish-tinged to the tip, 0.6–0.9 (–1) mm. long; styles appressed; leaves firm, the tertiary veinlets usually very obscure or invisible. . . . . ssp. *saxicola* (1c)
1. Branches quite smooth; disk of female flower entire or obscurely angled; calyx-lobes of female flower narrower, more acute, usually not red-tinged except at base; styles more or less ascending; leaves thinner, margin scarcely thickened, tertiary veinlets usually forming an evident reticulum beneath.
   2. Stipules 0.8–1.2 mm. long; disk-segments of male flower cuneate-squarish or roundish, as broad as or broader than long; leaves obovate, tapering from above middle to base; calyx-lobes of female flower mostly linear-spathulate, (0.9) 1–1.2 (–1.4) mm. long . . . . . ssp. *caroliniensis* (1a)
   2. Stipules 1.5–2 mm. long; disk-segments of male flower ovate or elliptic, mostly longer than broad; leaves more often elliptic, tapering at or below middle toward base; calyx-lobes of female flower oblong or spathulate, mostly 0.7–0.9 mm. long . . . . . ssp. *guianensis* (1b)

Another subspecies from Panama, Colombia, and perhaps other parts of South America may eventually be found in the West Indies. It is distinguished at once by its narrowly winged stems and is here designated as **Phyllanthus caroliniensis** ssp. **stenopterus** (Muell. Arg.) comb. nov. (*P. stenopterus* Muell. Arg. Prodr. **15**[2]: 399. 1866).

1a. **Phyllanthus caroliniensis** ssp. **caroliniensis.**
(PLATE XIII, *figs. A, B*).

Phyllanthus caroliniensis Walt. Fl. Car. 228. 1788.

Phyllanthus obovatus Muhl. ex Willd. Sp. Pl. **4**: 574. 1805.

Geminaria obovata Raf. First Cat. Bot. Gard. Transylv. Univ. 14. 1824.

Synexemia caroliniana Raf. Neogenyton 2. 1825.

Synexemia obovata Raf. ibid.

Synexemia pumila Raf. ibid.

Synexemia cuneifolia Raf. New Fl. N. Amer. **4**: 100. 1838.

Euphorbia ludoviciana Featherman, Bot. Surv. So. & Centr. La. 71. 1871.

Andrachne pumila (Raf.) House, Bull. N. Y. State Mus. **233–234**: 66. 1921.

Phyllanthus graminicola Britton, Bull. Torr. Bot. Club **48**: 333. 1922.

Erect annual herb 1–3 dm. high, primary stem with several to many lateral branches; branches smooth or furrowed, not scabridulous; stipules triangular-lanceolate, denticulate especially toward the base, thin and scarious, (0.8–) 1–1.2 mm. long, 0.5–0.6 mm. broad. Leaves obovate or elliptic, rounded and apiculate or obtuse at the tip, 6–13 mm. long, 4–7 mm. broad, smooth on both sides and margins; midrib above plane, beneath conspicuously raised (at least proximally), the laterals (4 or 5 on a side) forming with the tertiaries a delicate reticulum. Male flowers solitary, each associated with 2 or 3 females in the cymule, calyx-lobes 6, segments of the disk cuneate or squarish, as broad as or broader than long. Female flower: calyx-lobes 6, linear-lanceolate or narrowly spathulate, acute, green, (0.9–) 1–1.2 (–1.4) mm. long, 0.2–0.3 mm. broad; disk cupular, enclosing ⅓ to ½ the ovary at anthesis, entire. Capsule c. 1.7 mm. in diameter, green; seeds light greyish brown, 0.8 mm. long, 0.65 mm. radially (in West Indian specimens).

Type: Herb. Thomas Walter, sheet 83 (holotype in BM not seen, but photograph in GH library examined).

Distribution: more or less coextensive with the range of the species (Map I).

JAMAICA: St. Mary: Castleton grounds, alt. 500 ft., *Harris 12143* (F, GH, JAM, MO, US).

LESSER ANTILLES: Swan Islands: Eastern Swan Is., 17.22° N., growing in sand, *Lord Moyne 4* (NY). Martinique: *Bélanger 222* (P), *293* (G, P), *670* (P), *782* (P); *Duss 48* (ex p., mixed with ssp. *guianensis*, F, NY); cultures, Balata, *Mouret 113* (P). Tobago: The Widow, near Easterfield, on banks of the main road, *Broadway 3515* (F). Trinidad: hb. Hooker (P); Woodbrook, wild in garden, *Broadway 6675* (S); coastal plain, grassy roadside, Carenage, *Britton & Hazen 12* (NY, holotype of *P. graminicola*; GH, US, isotypes); swale, O'Meara Savanna, *N. L. & E. G. Britton 2502* (GH, TRIN).

The West Indian specimens of ssp. *caroliniensis* represent heterogeneous and sporadic populations; the specimens at least from Jamaica and Martinique have probably been introduced. The Trinidad form, made a separate species *P. graminicola* by Britton, has very narrow calyx lobes and small seeds but represents at most a rather unimportant variant of ssp. *caroliniensis*.

1b. **Phyllanthus caroliniensis** ssp. **guianensis** (Klotzsch) Webster[10] var. **antillanus** Muell. Arg. Linnaea **32**: 36. 1863.

[10] Contr. Gray Herb. **176**: 46. 1955.

Phyllanthus schomburgkianus β *antillanus* Muell. Arg. in DC. Prodr. **15**(2): 387. 1866.

Erect sparsely branched herb becoming 2–4.5 dm. high; branches smooth, often quite flattened above. Stipules rather narrowly triangular-lanceolate, acuminate, denticulate or entire, mostly 1.5–2 mm. long, c. 0.5–0.6 mm. broad. Leaf-blades elliptic to oblong or obovate, often broadest at or slightly below the middle, 8–22 mm. long, 4–10 mm. broad, smooth on both sides and on margins, thin, the reticulum of tertiary veinlets visible beneath. Male flowers paired (sometimes single?); calyx-lobes 6, disk-segments ovate or elliptic, definitely longer than broad, obscurely glandular at the tip. Female flowers 1 or 2 per axil; calyx-lobes 6, oblong to spathulate, acute or obtuse, green or reddish-tinged only at the base, 0.7–0.9 (–1) mm. long, (0.2–) 0.25–0.4 (–0.5) mm. broad; disk entire or roundly angled; styles free, ascending. Capsule c. 1.7–2 mm. in diameter; seed 0.9–1 mm. long, 0.75–0.8 mm. broad.

TYPE: Martinique, *Sieber Herb. Martin. Suppl. 10.*

DISTRIBUTION: var. *antillanus* is endemic to the Lesser Antilles (MAP I).

LESSER ANTILLES. ANTIGUA: *Wüllschlagel 496, 497* (GOET); Fig Tree Hill, a weed in the S.W. (volcanic) district, *Box 1226* (F, US). MONTSERRAT: weed in provision lands, alt. 1200 ft., *Shafer 178* (NY, US). GUADELOUPE: 1839, *Beaupertuis* (P); dans les champs cultivés, Camp Jacob, *Duss 2447b* (F, NY, US); *Quentin 254* (P). DOMINICA: woodlands on the western slopes of Morne Brule, Portsmouth, *Hodge 573A* (NY); Montpelier, *Lloyd 582* (NY). MARTINIQUE: 1858, *Bélanger 220* (P); 1867–70, *Hahn* (P); herb. Vaillant (P); S. Marie, *Bordas 7* (P); abondant le long des routes, Fonds St. Denis, Camp-Balata, &c., *Duss 48* (ex p., mixed with ssp. *caroliniensis*, F, NY, US); Herb. Martin. Suppl. 10, *Sieber* (L, W, SYNTYPES).

This plant is the Antillean representative of the South American ssp. *guianensis*, agreeing with var. *guianensis* in the stipules and male flowers and hardly differing in anything more than leaf shape. On Martinique var. *antillanus* occurs together with ssp. *caroliniensis*, which has presumably been introduced; there is no evidence that intergradation has occurred, but no careful field studies have been made. By virtue of its large stipules and elliptic disk segments in the male flower, ssp. *guianensis* is a very well-characterized group; but when the entire range of variation of *P. caroliniensis* is taken into account, it does not appear to warrant the rank of a separate species.

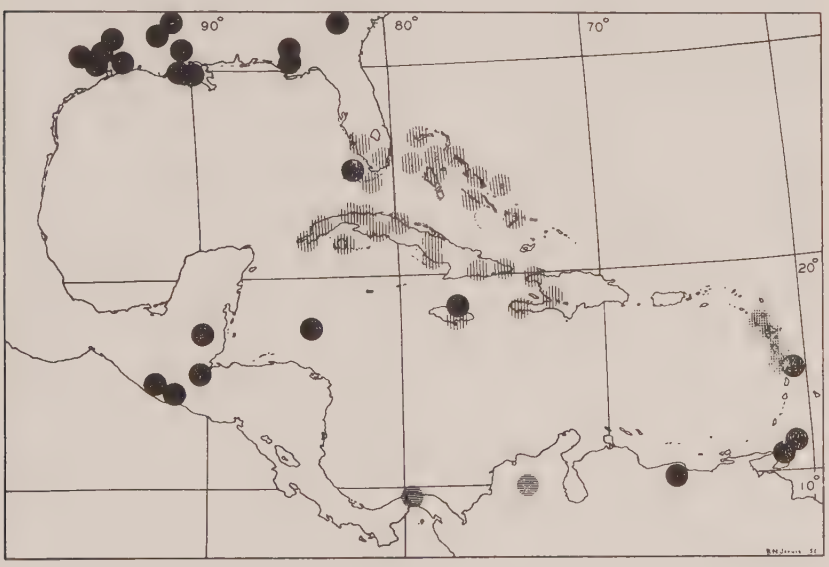
1c. **Phyllanthus caroliniensis** ssp. **saxicola** (Small) Webster, Contr. Gray Herb. **176**: 46. 1955. (PLATE XIII, *figs. C, D*).

Phyllanthus saxicola Small, Bull. N. Y. Bot. Gard. **3**: 428. 1905.

Phyllanthus pruinosus sensu Muell. Arg. in DC. Prodr. **15**(2): 387. 1866. Not *P. pruinosus* Rich. in Sagra, Hist. Nat. Cuba **11**: 216. 1850.

Erect annual or short-lived perennial, the primary stem either bearing pinnately arranged secondary branches or with few to several erect secondary branches clustered near its top; branches with minute papillae

either in discontinuous striae or densely arranged. Stipules triangular, acuminate, obscurely to conspicuously denticulate, (0.7–) 1–1.2 (–1.5) mm. long, 0.4–0.6 mm. broad. Leaf-blades narrowly elliptic to obovate, acute or more commonly obtuse or rounded-apiculate at the tip, acute at the base, 5–12 (–18) mm. long, 2–8 mm. broad, usually rather firm, bright green to olivaceous above, green to pallid beneath, secondary veins obscure above, usually evident and often raised beneath, tertiary veinlets ordinarily very obscure or quite invisible. Male flowers 1 or 2 per axil; calyx-lobes 6, olivaceous or infrequently reddish-tinged, c. 0.6–0.7 mm. long; disk-segments squarish or cuneate, about as broad as long. Female flowers 1 or 2 per axil; calyx-lobes 6 (rarely 5 or 7), mostly oblong to rather broadly spathulate and rounded to subacute at the tip, 0.6–0.9 (–1) mm. long, (0.2–) 0.3–0.5 (–0.6) mm. broad, green with pink-tinged scarious margins or often brilliantly red-stained, rarely lacking reddish color; disk usually lobed to irregularly or regularly divided into 6 cuneate or spathulate segments; styles more or less horizontally spreading. Capsule (1.5–) 1.6–1.75



Map I. Distribution of the Caribbean representatives of *Phyllanthus caroliniensis* Walt.: black dots, ssp. *caroliniensis*; vertical lines, ssp. *saxicola*; stippling, ssp. *guianensis* (var. *antillanus*); fine horizontal lines, ssp. *stenopterus*.

(–1.9) mm. in diameter, green or red-stained. Seeds (0.7–) 0.75–0.9 mm. long, 0.6–0.75 mm. radially and tangentially, dark-fuscous or light greyish brown.

Type: Florida, Dade County, everglades between Cocoanut Grove and Cutler, November 1903, *Small & Carter 775* (NY, holotype).

Distribution: southern Florida to Greater Antilles (Map I).

BAHAMAS: GREAT BAHAMA: rocky clearing, Eight Mile Rocks, *Britton & Millspaugh 2489* (F, NY); palmetto lands, Barnett's Point, *Britton & Millspaugh 2623* (GH, MO, NY, US). BIMINI: open sandy field, North Bimini, *R. A. & E. S. Howard 10014* (US). BERRY ISLANDS: Great Stirrup Cay, on limestone, *Britton & Millspaugh 2273* (F, NY); Great Harbor Cay, sandy soil, *Britton & Millspaugh 2333* (F, NY); Little Harbor Cay, cultivated ground, *Britton & Millspaugh 2250* (F, NY, US). ANDROS: northern section, coppice near Fresh Creek, *Small & Carter 8799* (F, GH, NY, US); Long Bay Cays, *Brace 5021* (F, NY); Kemp Bay, *Brace 5026* (F, NY). NEW PROVIDENCE: near Nassau, *Curtiss 79* (F, G, GH, L, M, MICH, MO, NY, P, US); Tea House, *E. G. Britton 3447* (NY); Hog Island, moist sandy places, *P. Wilson 8263, 8344* (F, MO, NY). ELEUTHERA: Governor's Harbor and vicinity, low meadow, *Britton & Millspaugh 5514 ex p.* (F); Glass Window to Harbor Island, thickets, *Britton & Millspaugh 5394* (F, NY); Harbor Island to the Bluff, *E. G. Britton 6504* (F, NY). EXUMA: Great Guana Cay, *Britton & Millspaugh 2861* (GH, NY, US). CAT ISLAND: Orange Creek and vicinity, white lands near Cotton Point, *Britton & Millspaugh 5746* (F, NY); the Bight and vicinity, moist ground, *Britton & Millspaugh 5928* (F, NY); Little San Salvador, red lands, *Britton & Millspaugh 5698* (F, NY). WATLING'S ISLAND: Cockburn Town, *P. Wilson 7207* (F, GH, NY), *Britton & Millspaugh 6076* (F, NY); southwest end, *P. Wilson 7337* (F, GH, MO, NY). ACKLIN'S ISLAND: Gold Rock, *Brace 4376* (F. NY).

CUBA: Without definite locality, *Poeppig* (P); *Wright 590* (BR, F, G, GH GOET, MO, NY, P, S, US), *591* (S). PINAR DEL RIO: Las Martinas to the coast, *Shafer 11095* (NY, US); banks of San Diego River not far from San Diego de los Baños, *León & Hioram 4519* (NY), *León 4411, 4553* (NY), *Roig 2330* (SV). ISLA DE PINOS: *Blain 174* (F); Caleta Cocodrilos, coastal limestone, *Britton, Wilson, & León 15293* (F, GH, MO, NY, US). HABANA: cerca de Rincón, *Wilson 1055* (NY); coastal sands between Río Cojimar and Playa de Bacuranao, *P. Wilson 9529* (NY); valley of Cuente Blanca River near Guanabacoa, *León 500* (NY); banks of Quibú River, Marianao, *León 3674* (NY, SV); inter Campo Florido et Loma de Coca, *Ekman 1242* (S). MATANZAS: along railroad near Ibarra, *Britton, Britton, & Shafer 340* (NY); prope Matanzas, *Rugel 292* (NY); in graminos humides, in pratis salsis ad Matanzas, *Poeppig* (BR, MO, P, W). LAS VILLAS: Ciénaga de Zapata, montes, Santo Tomas, *Acuña 4333* (SV); a orillas rio Caibarién, *Fernando 482* (NY). CAMAGÜEY: savanna north of La Gloria, in grass, *Shafer 360* (NY, US); Santa Cruz del Sur ad Río Najassa, *Ekman 8612* (S). ORIENTE: Bayate, border of Río Cauto, *Ekman 1964, 2442* (S); Sierra Maestra, *León 10748* (NY); Sevilla Estate near Santiago, upper Guama River, alt. 550 ft., *N. Taylor 164* (NY); steep banks of the Río Jojo c. 7 km. north of Cajovavo, *Webster 4000* (MICH); stony banks of Jauco River, Jauco, *León 11686* (NY); gorge of the Río Yamurí, in sandy crevices of rock near the river, *Shafer 7853* (NY); vicinity of Baracoa, in yard, *Shafer 3906* (NY); playa de Mata, Baracoa, *Acuña & Diaz Barreto 18615* (SV); Baracoa, between Yumurí and Mata, on shady limestone rock, *Ekman 3646* (S).

JAMAICA: ST. CATHERINE: Spanish Town, in damp hollows, *Harris 12046* (C, F, GH, JAM, MO, NY, P, S, US).

HAITI: NORD-OUEST: rocky bed of Môle Road, west bank of Riv. Côte de Fer, *E. C. & G. M. Leonard 12751* (US); vicinity of Jean Rabel, dry bed of Môle road on west bank of Riv. Côte de Fer, *E. C. & G. M. Leonard 13687* (NY, US); vicinity of Port à L'Ecu, bare mountain slope facing sea, west of bay, *E. C. & G. M. Leonard 13879* (GH, K, MO, NY, US); Presqu'île, Port-de-

Paix, limestone terraces west of Saline-Michel, quite rare, *Ekman H3948* (S). Ouest: arid coastal thicket west of Cabaret, *E. C. & G. M. Leonard 11838* (GH, K, MO, NY, US). Sud: Massif de la Hotte, western group, Pestel, Dalcour, laterite soil, c. 400 m., *Ekman H9011* (S, US).

DOMINICAN REPUBLIC: Barrabas [province not indicated], *Raunkiaer 784* (C).

This subspecies of southern Florida, the Bahamas, and the Greater Antilles is perplexingly variable and eventually may be divided into several varieties. It grows in a wide variety of habitats including pinelands on limestone, salty meadows, sandy wastes, abandoned fields, etc., with perhaps an overall preference for rocky, shaded streambeds. The plants from southern Florida (at the type locality) and from Great Bahama Cay comprise a geographic race which differs from most of the rest of the subspecies by virtue of darker seeds, red-tinged male flowers, and more depauperate habit. These characters can scarcely be defined well enough for purposes of identification, however. Moreover, since there are in Cuba and Haiti a number of aberrant types, it does not seem practicable to describe outlying segments of the main population as varieties. Some collections, particularly those from Haiti, have scarcely scabridulous stems (even with close inspection under a lens!) and are thus hardly separable from ssp. *caroliniensis*.

2. **Phyllanthus hyssopifolioides** HBK. Nov. Gen. & Sp. 2: 108. 1817. (PLATE XIII, *figs. E–G*).

Phyllanthus hyssopifolius Muell. Arg. in DC. Prodr. **15**(2): 390. 1866, sphalm.
Diasperus hyssopifolius ("HBK.") O. Ktze. Rev. Gen. **2**: 599. 1891.
Phyllanthus monocladus Urb. Repert. Sp. Nov. **15**: 404–405. 1919.

Erect annual herb, completely smooth and glabrous; main stem unbranched or with very few laterals, 1–2.5 dm. high, 0.5–1 mm. in diameter, light brown, below terete, above becoming flattened and with a thin narrow wing c. 0.1–0.15 mm. broad at the margins; internodes 5–9 mm. long. Leaves: stipules ovate-lanceolate, acuminate, auriculate, more or less denticulate, midrib area as in *P. heliotropus*, 1.2–1.5 mm. long, 0.6–0.7 mm. broad. Petioles 0.5–0.8 mm. long, plano-convex, adaxially grooved. Leaf-blades ovate, oblong, or elliptic, obtuse-apiculate at the tip, obtuse to rounded at the base, 6–12 mm. long, 2.5–5 mm. broad; above olivaceous, beneath pallid, green, or dull reddish; midrib raised above and beneath, laterals 4 or 5 on a side, obscure but usually visible above, beneath visible or obsolete; margin smooth.

Monoecious (sometimes dioecious?), the male and female flowers at separate axils, the male in few-flowered clusters (sometimes apparently solitary at branch-tips), the female solitary; male and female flowers irregularly alternating, with occasional axils barren.

Male flower: pedicel c. 0.5 mm. long. Calyx-lobes 5, obovate to orbicular or broader than long, rounded, entire, 0.6–0.7 mm. long, 0.6–0.9 mm. broad, scarious-hyaline, pale yellowish, the midrib unbranched, no herbace-

ous midstrip developed. Disk-segments 5, cuneate to orbicular, inconspicuously crenulate, rather thin, not evidently glandular, c. 0.2 mm. in diameter. Stamens 3, filaments free, c. 0.15 mm. long, obliquely ascending; anthers subglobose, 0.25–0.3 mm. broad, the slits confluent.

Female flower: pedicel 1 mm. long or less, geniculate. Calyx-lobes 6, oblong to obovate-oblong, obtuse or subacute, (0.8–) 1–1.2 mm. long, 0.4–0.7 mm. broad. Disk of 6 cuneate entire segments. Ovary smooth; styles horizontal, bifid, the greatly dilated and thickened branches spreading and appressed on the top of the ovary, less than 0.2 mm. long.

Capsule subglobose, c. 1.9 mm. high and 3 mm. broad, olivaceous, not veined. Seed bluntly trigonous, 1.6–1.7 mm. long, 1.4–1.5 mm. radially and tangentially, dull chestnut-brown with a thin easily rubbed-off yellowish coating, quite smooth, the ornamentation due to the outlines of the wavy rows of longitudinally elongated cells; hilum circular, purplish-black.

TYPE: Venezuela, Orinoco region, Santa Barbara, Maypure, *Humboldt* (Herb. Humboldt, P).

DISTRIBUTION: savannas, Hispaniola and northern South America (MAP II).

DOMINICAN REPUBLIC. DUARTE: Cordillera Septentrional, Matanzas, Sabana del Pinal, not common, *Ekman H15878* (S). TRUJILLO: savannah land and lake area between Bayaguana and Guerra, *R. A. & E. S. Howard 9934* (US). SEIBO: Cordillera Central, Sabana de la Mar, in savannas, not common, *Ekman H15612* (S; this locality originally in Prov. Samaná).

TRINIDAD: Piarco Savanna, *Crueger* (GH), *Baker* (TRIN 14854); O'Meara Savanna, *Britton & Hazen 1573* (TRIN), *Broadway* (TRIN 9341).

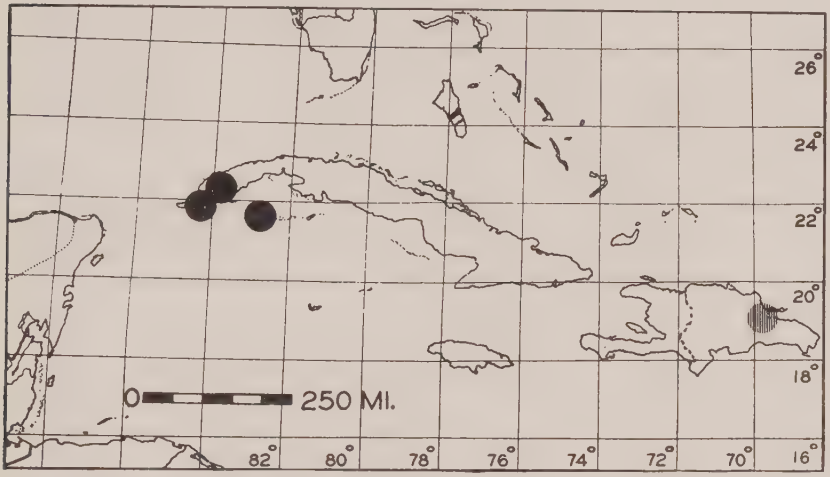
The identification of the specimens from Hispaniola as this characteristically South American species is one of the more surprising phytogeographic discoveries made during this study. The material collected by Ekman and the Howards matches Mueller's description in the "Prodromus" (1866: 390) in all essential details. The very characteristic seeds, present in the mature condition in both Ekman collections, establish the identity of the Hispaniolan plant beyond doubt. The type specimen in Humboldt's herbarium in Paris differs from the West Indian plants in the small capsule (c. 2.5 mm. in diameter) and calyx-lobes only 0.7–0.8 mm. long, but nevertheless appears clearly to be conspecific.

Although *Broadway 2130* from Piarco Savanna, Trinidad — the type collection of *P. monocladus* Urb. — has not been examined, the Crueger specimen from the same locality surely represents the same population. The Trinidad plants differ from the Hispaniolan ones only in their somewhat smaller size, while they correspond in all the technical characters. *Phyllanthus monocladus* may therefore be relegated to synonymy with confidence.

3. **Phyllanthus heliotropus** Wright ex Griseb. Goett. Nachr. **1865**: 167. 1865; emend. Muell. Arg. in DC. Prodr. **15**(2): 388. 1866. **(PLATE XIV).**

Diasperus heliotropus ("Gris. em.") O. Ktze. Rev. Gen. 2: 599. 1891.

Erect perennial (but flowering the first year), entirely smooth and glabrous, the primary axis becoming a thickened, dark-brown caudex up to 1–2 cm. long and 5 mm. thick, with few to many somewhat thick subsimple or branched dark brown lateral roots. Stems clustered atop the caudex, unbranched or with one or very few laterals, becoming mostly 3–5 (–7) dm. high, c. 1–1.5 mm. thick, greenish brown to deep chestnut



Map II. Distribution of *Phyllanthus heliotropus* Wright ex Griseb. (black dots) and *P. hyssopifolioides* HBK. (lined dots) in the Greater Antilles.

brown, more or less terete at the very base but above soon flattened and with a narrow sharp wing 0.1–0.2 mm. wide, or merely acute-angled near ends of branches; internodes variable, decreasing in length from c. 7–15 mm. at base of large stems to c. 3–5 mm. at tips and on smaller stems. Stipules ovate-lanceolate, acuminate, auriculate, obscurely to conspicuously dentate, the midvein of the thickened dark basal median area extending as a conspicuous rib through the light to dark brown scarious margins, (1–) 1.3–1.7 (–2) mm. long, 0.5–0.9 mm. broad. Leaves: petioles plano-convex, grooved above, 0.7–1 mm. long, dark brown. Blades mostly oblong or sometimes ovate or elliptic, obtuse and mucronate at the tip, obtuse or rounded at the base, those on main stems mostly 5–12 mm. long and 2.5–6 mm. broad (somewhat smaller at tips and on smaller branches), subcoriaceous, bright to dull olivaceous above, olivaceous to reddish-bronzen or silvery beneath, the midrib depressed but visible above, salient and running to the mucro beneath; margin thickened, smooth or with irregular thickenings.

Dioecious or subdioecious (rarely monoecious), sporadic female flowers occasionally appearing on otherwise male plants, the female and male flowers always at different axils; female flowers solitary (rarely paired):

male flowers in densely bracteolate monochasia eventually becoming 1–2 mm. long (but appearing as if in clusters of 2 or 3 at tips of branches or on plants flowering the first year).

Male flower: pedicel slender, 0.6–0.8 mm. long above the articulation. Calyx-lobes 5 or 6, oblong to obovate or suborbicular, rounded-obtuse to subtruncate, entire, (0.6–) 0.7–0.8 (–1) mm. long, 0.6–0.9 (–1) mm. broad, the yellowish scarious margins broader than the narrow to obsolete greenish midstrip; midrib unbranched, running to the tip. Disk-segments 5 or 6, orbicular to cuneate, 0.25–0.35 mm. long, entire or obscurely wavy, not evidently glandular. Stamens 3, completely free (very rarely united halfway), 0.3–0.5 mm. long, obliquely ascending; anthers swollen adaxially at the top of the filament (thus appearing globose from behind), 0.2–0.25 mm. long, 0.25–0.4 mm. broad; anther-sacs discrete, opening horizontally and transversely.

Female flower: pedicel geniculate, becoming c. 1 mm. long, reddish. Calyx reddish-tinged, massive at the base; calyx-lobes 5 or 6, ovate to oblong in flower, oblong to oblong-ovate in fruit, rounded or obtuse, entire, (0.9–) 1–1.3 mm. long, (0.5–) 0.6–0.75 (–0.9) mm. broad, spreading or reflexed, midstrip dark green but usually deeply reddish-stained, scarious margins broad; midrib plane without, salient within. Disk cut to the base into 5 or 6 squarish or cuneate more or less emarginate segments c. 0.35–0.4 mm. in diameter, these yellowish, rather thick, smooth and nearly entire, not evidently glandular. Ovary smooth, deeply sulcate; styles free, erect-ascending, c. ⅓–fid, c. 0.35 mm. long, 0.2 mm. wide across the thick and fleshy divaricate and recurved branches.

Capsule depressed-globose, c. 1.7 mm. high, (2.7–) 2.8–3 mm. broad, deep lavender-reddish, no nervation visible on sides. Seeds trigonous, (1.3–) 1.35–1.55 mm. long, (1–) 1.2–1.3 (–1.4) mm. radially, 1–1.3 mm. tangentially, chestnut-brown to fuscous, lucid becoming dull, with scattered raised black points; hilum dark purplish-brown, triangular or roundish.

TYPE: Cuba, Pinar del Rio, *Wright 1945* (GOET, HOLOTYPE; F, G, GH, NY, P, S, US, ISOTYPES). The collection in the Gray Herbarium has in a packet manuscript notes by Wright indicating the localities as: "savannas, Vueltabajo", and "Pinales Hatequemado". "Vueltabajo", however, is merely a general name for a large stretch of tobacco-growing country in Pinar del Rio; and the Pinales Hatequemado have not been identified.

DISTRIBUTION: endemic to Cuba and the Isle of Pines (MAP II).

CUBA: PINAR DEL RIO: *Wright 1945* (GOET, HOLOTYPE; F, G, GH, NY, P, S, US, ISOTYPES); Laguna Santa María, wet sand, *Britton, Britton, & Gager 7184* (NY); Laguna Jovero, dry sand, *Shafer 10708* (F, NY, US); Laguna Los Indios and vicinity, in water, *Shafer 10804* (NY); between Guane and Remates, sabanas near El Payuco, *Killip 32363* (GH, US); savanes de San Luis, *Marie-Victorin & Alain 326, 354* (MT); Laguna Redonda, between Pinar del Río City and La Coloma, fairly common in white sand, *Webster 4672* (GH, MICH); between Pinar del Río and Coloma, Colpothrinax savanna, *Britton et al. 6608*

(F, NY); Herradura, in sandy pinelands, *Ekman 10735* (S). Isla de Pinos: Santa Barbara, Colpothrinax savanna south of railroad, *Earle* (NY); Nueva Gerona, edge of cultivation, *Curtiss* (NY); Prendio Modelo, Nueva Gerona, sabanas, *Roig 8806* (SV); Columbia, in low moist sandy pinelands, edge of a pond, *Ekman 12396* (S); vicinity of Los Indios, white sand, *Britton, Britton, & Wilson 14174* (F, NY, US).

This plant, characteristic of savannas and pinelands of western Cuba, takes its specific epithet from Wright's manuscript notes that the plant "spreads its leaves to the morning sun". It is related on the one hand to *P. pudens* Wheeler of Texas, but also to *P. hyssopifolioides*. In seed characters it agrees with the former but in the male flower and in fruit size it approaches more closely to the latter. It is also related to the widespread *P. compressus* which, however, is monoecious and has monadelphous stamens. These species, together with a few others of South America, comprise a complex whose distribution pattern parallels that of the subspecies of *P. caroliniensis*; but in this case the differentiation between the groups is so pronounced that they certainly represent distinct species.

(*To be continued*)

EXPLANATION OF PLATES

PLATE XIII

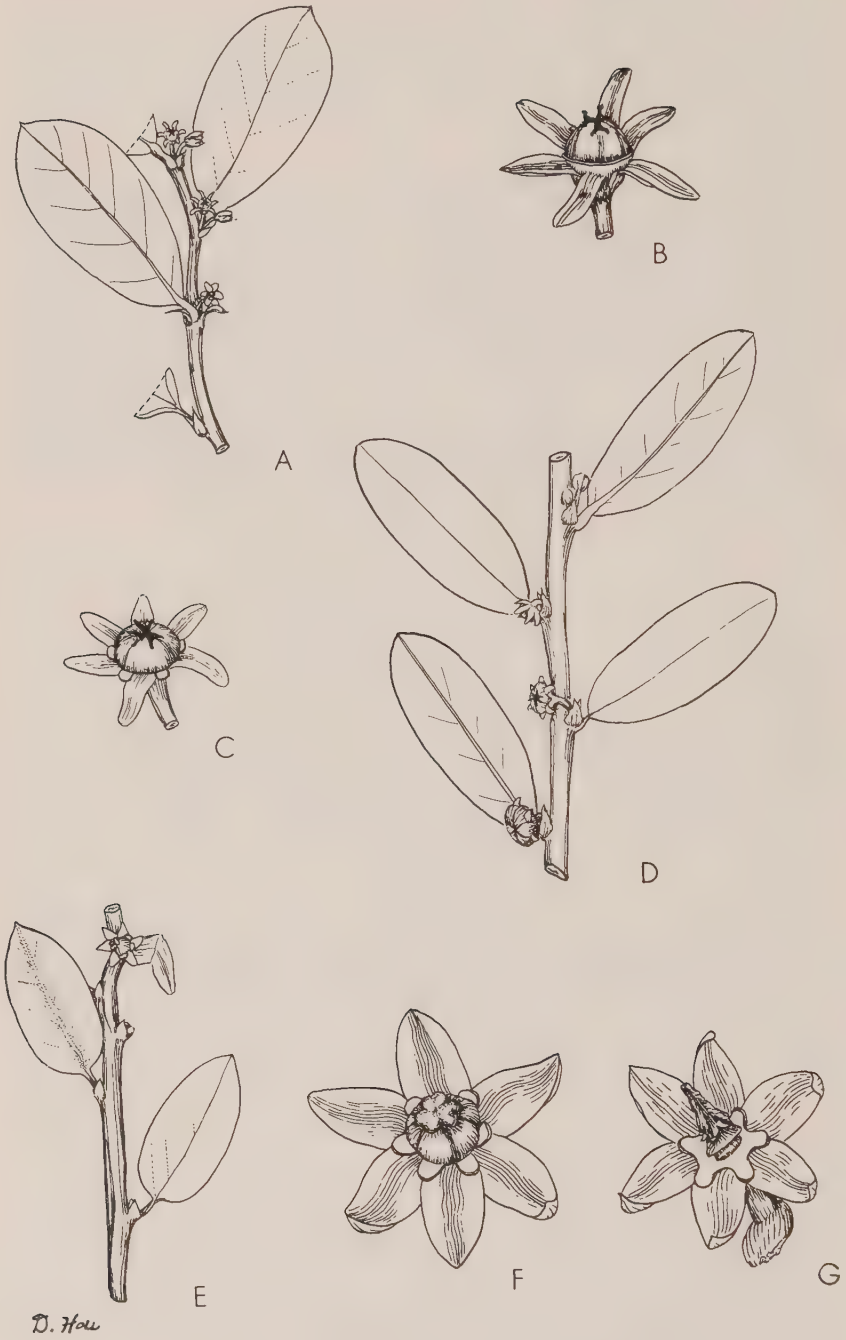
Figs. A–B. *Phyllanthus caroliniensis* ssp. *caroliniensis* (*Harris 12143* [GH]): A. branch, × 4; B. female flower, × 10.

Figs. C–D. *Phyllanthus caroliniensis* ssp. *saxicola* (*Small & Carter 8799* [GH]): C. female flower, × 10; D. branch, × 4.

Figs. E–G. *Phyllanthus hyssopifolioides* (*Baker 14854* [TRIN]): E. branch, × 4; F. female flower, × 10; G. fruiting calyx, × 10.

PLATE XIV

Phyllanthus heliotropus Wright ex Griseb. (*Killip 32363* [GH], figs. A–B, D–E; *Webster 4672* [GH], fig. C): A. habit, c. ½ natural size; B. branch, × 5; C. male flower, × 20; D. female flower, after fertilization, × 10; E. seed, × 8.



WEBSTER. WEST INDIAN PHYLLANTHUS

Webster, West Indian Phyllanthus

THE RELATIONSHIP BETWEEN SPHENOSTEMON OF NEW CALEDONIA AND NOUHUYSIA OF NEW GUINEA

I. W. BAILEY

IN REDUCING THE GENUS *Nouhuysia* to *Sphenostemon* — as a basis for emphasizing a closer relationship between the floras of New Guinea and New Caledonia — Van Steenis (7) concluded his brief paper with the statement, "it is still desirable that the wood anatomy be examined." Having published with Dr. Swamy (1) a detailed study of the endomorphic structures of *Nouhuysia* and of the congeneric *Idenburgia* I proceeded to assemble material of the three known species of *Sphenostemon* for a comparative investigation. In so doing, I was unaware of the fact that Dr. Metcalfe had undertaken, at the suggestion of Professor Erdtman, a study of the anatomy of the stems and leaves of *Sphenostemon*. Doctor Metcalfe has kindly sent me an advance copy of his manuscript. Since I am in complete agreement with his descriptions and conclusions, I shall not attempt to record in detail my own observations upon the anatomy of the vegetative organs of *Sphenostemon*, but shall confine my attention primarily to the reproductive ones.

A totality of available evidence from leaves and small stems of herbarium specimens is clearly indicative of close relationship between *Sphenostemon* and *Nouhuysia*. Particularly significant are similarities in the occurrence and distribution of styloids, in nodal anatomy (trilacunar), in vasculature of the leaf (characteristic more or less triangular stele in the petiole and midrib of the lamina), and in the primitive structure of the first-formed secondary xylem. However, as concluded by Metcalfe (6) available anatomical evidence is insufficient for determining whether the genera are congeneric. In this connection, it is desirable to obtain material from the outer parts of large stems as such material frequently exhibits a wider range of structural differences than do the first-formed secondary tissues of small twigs.

MATERIAL

My investigation of the reproductive structures of *Sphenostemon* is based upon material obtained from the following herbarium specimens: *Sphenostemon balansae* Baill. (*Balansa 1330*), flowers, pollen. *Sphenostemon comptonii* Baker (*Compton 1693*), flowers, pollen. *Sphenostemon pachycladum* Baill. (*Buchholz 1297*), flowers, pollen, fruits; (*Franc* in Herb. Arnold Arb.), flowers, pollen.

The extensive collections of *Idenburgia* and *Nouhuysia* utilized for comparative purposes are listed in the paper by Bailey and Swamy (1).

POLLEN

In commenting upon *Sphenostemon* at the VIII[th] International Botanical Congress, Erdtman (4) suggested that "it might be worth while to investigate whether or not the similarity between the strange pollen grains in this genus and those in *Idenburgia* (or *Nouhuysia*), another genus of uncertain taxonomic position from New Guinea, is taxonomically significant." His suggestion appears to have been based upon a comparison between the pollen of *Sphenostemon balansae* Baill. (*Balansa 1330*) and that of *Nouhuysia papuana* Laut. (*Kostermans 2198*).

When examined in water or lactic acid, the pollen grains of the three species of *Sphenostemon* are closely similar in size ($\pm$ 10 $\times$ 13 μ), in form (oblate) and in structure (3-porate and conspicuously reticulate at magnifications of 600–1500). The pores or apertures in the nexine are relatively large for grains of such comparatively small size and are circular or oval, the orientation of the latter varying from lolongate to lalongate. The polar sexine, as noted by Erdtman (5), is at times thinner with faint or absent reticulation. Each pore is subtended by a plug of colorless, transparent, hygroscopic material which expands when moistened, bulging the tenuous sexinous covering outward. This hyaline substance removes ruthenium red very rapidly from dilute solutions in advance of the gradual deeper staining of the protoplast. In this respect, it resembles the papillae which project from moistened pollen of the New World species of *Drimys*, Bailey and Nast (2).

As previously shown by Bailey and Swamy (1), the pollen of *Nouhuysia* varies markedly in size, form, and structure. The large ($\pm$ 35 μ), spherical, nonaperturate grains of *Brass 12661* and *Clemens 5499b* have a conspicuously thickened nexine. The tenuous sexine has a faintly detectable pitted or granular appearance at high magnification. The pollen of other collections of *Nouhuysia* differs in being smaller, oblate and provided with conspicuous pores of varying size, number and orientation. The grains of *Clemens 2422* are 4-porate with an admixture of 5-porate ones, those of *Rutten 2240* are 4-porate with an admixture of 3-porate grains and those of *Kostermans 2217*, *Kostermans 2198*, and *Gibbs 5654* are 3-porate with an admixture of 4-porate ones. The transparent material, which subtends the pores, varies in amount and in the case of the relatively small apertures of more or less circular form in *Kostermans 2217*, *Clemens 2422* and *Rutten 2240* is only slightly protuberant when the pollen is moistened, in contrast to the conspicuous protrusions that occur through the larger, oval, usually lolongate pores of *Kostermans 2198* and *Gibbs 5654*. The pollen from *Kostermans 2217* and *Clemens 2422* have a clearly visible reticulate sexine, but of finer texture than that of *Sphenostemon*. This is in contrast to the sexine of *Clemens 3828*, *Kostermans 2198*, *Gibbs 5654* and *Rutten 2240* which has a faintly visible sculpture at high magnification, thus resembling that of the nonaperturate pollen of *Brass 12661* and *Clemens 5499b*.

Although the pollen from each collection of *Nouhuysia* differs from that

of *Sphenostemon* in one or more of its morphological characters, there is a combination of diagnostic criteria in the genus as a whole which, as noted by Erdtman (4), is strongly suggestive of relationship between *Nouhuysia* and *Sphenostemon*. However, evidence from pollen *by itself* is at present inadequate for determining whether the two categories of plants are congeneric.

STAMENS

The stamens of the three species of *Sphenostemon*, as in the case of the stamens of *Degeneria*, *Himantandra* and a number of other ranalian (sensu lato) genera, cannot be described adequately in conventional terms of filament, anther and connective. They are relatively broad,[1] fleshy micro-

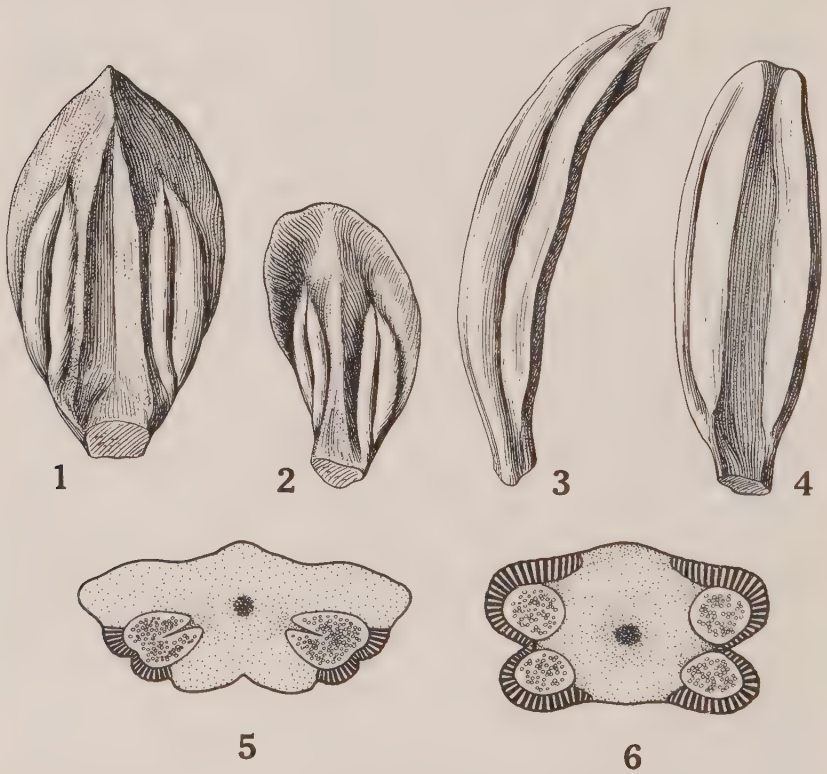


FIG. 1. Stamen of *Sphenostemon pachycladum* Baill. (*Buchholz 1297*), × 15. FIG. 2. Stamen of *S. comptonii* Baker (*Compton 1693*), × 15. FIGS. 3 & 4. Stamens of *Nouhuysia* (*Kostermans 2198*), × 15. FIG. 5. Transverse section of stamen in FIG. 1, × 25. FIG. 6. Transverse section of stamen in FIG. 4. × 25.

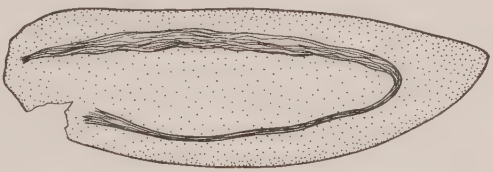
[1] It should be noted in this connection that the normal form of the stamens, i. e. where they are able to expand symmetrically, is frequently modified by excessive lateral pressures of expanding, closely congested organs in the flower buds.

sporophylls, *Figs. 1 & 2*, having deeply embedded sporangia, *Fig. 5*. As in the case of *Degeneria* and *Himantandra*, the fibrous parts of the hypodermis ("endothecium") are restricted to limited areas confronting the sporangia, *Fig. 5*.

In contrast, the stamens of *Nouhuysia* resemble sessile conventional anthers with extensive, markedly protuberant sporangia, *Figs. 3, 4 & 6*. The fibrous parts of the hypodermis are more extensive, *Fig. 6*, in certain collections, e. g. *Clemens 2422*, jacketing the exposed surfaces of the "connective" as well as confronting the protuberant parts of the sporangia.

SEEDS

The seeds of all investigated collections of *Nouhuysia*, and of the congeneric *Idenburgia*, are characterized by a centripetally, deeply lobed stony layer with a corresponding conspicuously ruminate nutritive layer, *Fig. 9*. The vascular system consists of a number of strands, or branches from the supply at the base of the seed. In *Fig. 9*, there are seven such strands, each corresponding with one of the major ruminations of the nutritive layer. The embryo is rudimentary and minute.



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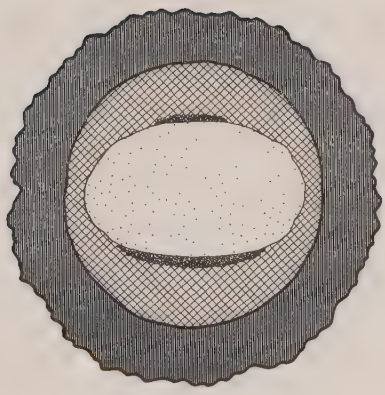

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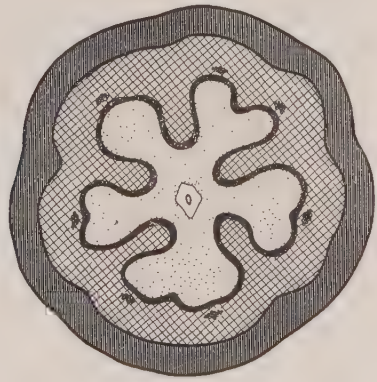

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FIG. 7. Cleared seed of *S. pachycladum* Baill. (*Buchholz 1297*), showing pattern of vasculature, × 5. FIG. 8. Transverse section of fruit and seed of *S. pachycladum* Baill. (*Buchholz 1297*), × 10. FIG. 9. Transverse section of fruit and seed of *Nouhuysia* (*Clemens 2240*), × 9; carpellary wall dark, stony layer cross-hatched, nutritive layer stippled, vascular strands dark.

The dry fruits of *Sphenostemon pachycladum* Baill., *Buchholz 1257*, are of much elongated form (22 × 6 mm.) in contrast to the more or less globose (12 × 10 mm.) or subglobose (15 × 12 mm.) fruits of *Nouhuysia*. The correspondingly elongated seeds contract markedly in drying, but even when reexpanded the sclerotesta and nutritive layers exhibit no evidence of lobing or rumination, *Fig. 8*. The vascular tissue is in the form of a *single* broad band which extends from the base of the seed toward the apex and back again toward the level of attachment of the seed, *Figs. 7 & 8*. That the absence of rumination is not due to immaturity of the fruit is indicated by the fact that rumination of the undifferentiated tissues of *Nouhuysia* is detectable during early stages of the enlargement of the seeds.

DISCUSSION

Evidence from all organs is clearly indicative of close relationship between *Sphenostemon* and *Nouhuysia*. The most conspicuous differences between the two categories of plants are in the reproductive, rather than in the vegetative, organs. The problem of the congeneric status of the genera resolves itself, accordingly, into a matter of consistency in taxonomic judgments. Does the totality of morphological differences exceed the limits of a single generic boundary?

The most outstanding and consistent differences between available collections from New Caledonia and those from New Guinea are at present in the stamens. However, if the seeds of *S. comptonii* Baker and *S. balansae* Baill. resemble those of *S. pachycladum* Baill., fundamental differences in vasculature and rumination may eventually prove to be equally, if not more, significant taxonomically.

It should be noted in this connection that broad microsporophylls with more or less deeply embedded sporangia occur in various representatives of the Magnoliaceae, as well as in *Degeneria* and *Himantandra*. As demonstrated by Canright (3) the chief specializations in the stamens of the Magnoliaceae (sensu stricto) appear to be (1) elongation of the apices, (2) differentiation of a filament, (3) reduction in the number of veins from three to one, (4) an increase in the relative size of the sporangia and a concomitant increase in their amount of protuberance, (5) transition from a laminal to a marginal position of the sporangia, and (6) development of an enveloping fibrous layer in the "connective." It is evident that the differences between the stamens of *Sphenostemon* and those of *Nouhuysia* involve changes comparable to items 4–6 in the Magnoliaceae. If broad sessile microsporophylls with deeply embedded sporangia, e. g. *Magnolia maingayi* King, are to be retained in the genus *Magnolia,* it might not be inconsistent taxonomically to reduce *Nouhuysia* to *Sphenostemon*. However, it seems that final judgment in such matters should be based upon the totality of evidence from all parts of the plant rather than upon similarities or differences in any single organ or morphological feature.

When the differences in the stamens are considered in connection with differences in the pollen, in the seeds, and in the perianth (*Nouhuysia*, 4

tepals or "sepals"?, *Sphenostemon*, 8 tepals or 4 "sepals"? + 4 "petals"?) it appears premature to reduce *Nouhuysia* to *Sphenostemon* until additional material of the plants has been collected and carefully investigated. Furthermore, striking differences in the pollen from different collections of *Nouhuysia* raises the question whether all of them can be included in *N. papuana* Laut.

It should be emphasized in conclusion that the microsporophylls of *Sphenostemon* and the very primitive structure of the xylem in both *Nouhuysia* and *Sphenostemon* make these genera unusually significant phylogenetically. They clearly do not belong in the Guttiferae or Trimeniaceae and it seems unlikely that they are closely related to the Aquifoliaceae. More comprehensive investigations of adequately preserved material are essential for determining their true relationships.

ACKNOWLEDGMENTS

I am much indebted to Dr. George Taylor of the British Museum for his courtesy in sending material of *Sphenostemon comptonii* Baker, to Professor G. Neville Jones for specimens of *S. pachycladum* Baill. collected by Buchholz, and to the Paris Museum of Natural History for the loan of various collections of *Sphenostemon*.

LITERATURE CITED

1. Bailey, I. W. and B. G. L. Swamy. The morphology and relationships of Idenburgia and Nouhuysia. Jour. Arnold Arb. **34**: 77–85. 1953.
2. ——— and C. G. Nast. The comparative morphology of the Winteraceae I. Pollen and Stamens. Jour. Arnold Arb. **24**: 340–346. 1943.
3. Canright, J. E. The comparative morphology and relationships of the Magnoliaceae I. Trends of specialization in the stamens. Amer. Jour. Bot. **39**: 484–497. 1952.
4. Erdtman, G. Palynology and plant taxonomy, VIII^{e} Cong. Inst. Bot. Rapp & Comm. Sect. **4**: 33. 1954.
5. ———. Pollen morphology and plant taxonomy. Chronica Botanica Co. 1952.
6. Metcalfe, C. R. The taxonomic affinities of Sphenostemon in the light of the anatomy of its stem and leaf. In press.
7. Steenis, C. G. G. J. van. Some notes on the flora of New Caledonia and reduction of Nouhuysia to Sphenostemon. Svensk Bot. Tidskr. **49**: 19–23. 1955.

THE CONDUPLICATE CARPEL OF CANANGA ODORATA

K. PERIASAMY AND B. G. L. SWAMY

RECENT INVESTIGATIONS by Prof. I. W. Bailey and his colleagues on the representatives of the ranalean families have brought to light several features of great morphological value. Among the more important of these is the concept of the "conduplicate carpel," first put forward by Bailey and Smith (1942), Bailey and Nast (1943), and further elaborated by Bailey and Swamy (1951).

The concept of the conduplicate carpel was primarily the outcome of an effort to understand and interpret the remarkable megasporophyll of the Degeneriaceae, a new family recently added to the Ranales (Bailey and Smith, 1942). According to Bailey and Smith, "The carpel of *Degeneria*, preceding and during anthesis, resembles an adaxially folded 3-veined sporophyll. . . . Furthermore, the margins of the carpel are not infolded or coherent during ontogeny, but tend to flare apart externally. The placentation is clearly laminar and adaxial." This remarkable nature of the carpel of *Degeneria* instigated further investigations, and Bailey and Nast (1943) found that not only carpels of a fundamentally similar type occur in the representatives of the Winteraceae, but that this family as a whole exhibits also various trends of phylogenetic modifications of such primitive ranalean megasporophylls. As a result of their investigations on the Degeneriaceae and Winteraceae, Bailey and Nast (1943) concluded that the carpels of these families "do not conform with the classical interpretation of the angiosperm carpel as an involute megasporophyll bearing marginally attached ovules." Following this, Bailey and Swamy (1951) have given a clear and coherent picture of the course of carpel evolution in the Ranales. They have shown that, proceeding from the least modified form of surviving carpel exhibited by *Drimys piperita*, the various other morphological forms may be derived as logical consequences of certain simple trends of modification.

Although the evidences presented in the contributions cited above are sufficient to warrant a modification of the "classical" view of the carpel which comprehends the megasporophyll of angiosperms as an involute structure with marginal placentation, it is desirable to present further evidence which would strengthen the "conduplicate" view.

The primodia of the carpels of the annonaceous *Cananga odorata* (Lam.) Hook. f. & Thoms. arise as peg-like projections from the central region of the somewhat flat thalamus. In a transection, each primordium appears as a solid structure. The adaxial part consists of richly cytoplasmic, meristematic cells, but there is a gradually increasing vacuolation in the cells as one proceeds towards the abaxial face (FIG. 1). As development proceeds, the primordium assumes a roughly triangular outline in transection, with a flattened adaxial side and a more or less conical abaxial side. The

densely protoplasmic meristematic cells become isolated in two masses along the adaxial side. At the same time, a majority of cells in the abaxial part become highly vacuolate and parenchymatous (Fig. 2). During slightly later stages of differentiation, the marked activity of the two masses of marginal meristems (essentially by periclinal divisions) along the adaxial side brings about the formation of a median longitudinal furrow. In a transection, the furrow appears as a notch, and the two free arms consist of active meristematic cells. The procambium of the median vascular strand of the carpel is also noticeable at this time (Fig. 3). The marginal meristems continue their activity for a time, and as a result, the free arms become longer and the furrow deeper (Fig. 4). Soon, however, there is a cessation of the activity of the meristems and this is indicated by the onset of vacuolation in the hypodermal cell layers of the free arms (Figs. 4, 5).

The early ontogenetic stages of the carpel of *Cananga odorata* just described, show striking resemblances to the development of a simple leaf as described by Foster (1936). According to Foster a leaf primordium, soon after its appearance at the growing point, is "pad-like or peg-shaped." Then, "following the early specialisation of the petiolar midrib region in most simple leaves, the lamina begins to differentiate from its upper portion as two thin marginal ridges of meristems." A comparison of Fig. 3 of Foster (1936) with Fig. 3. of our paper makes it evident that the marginal meristems in both structures are not only homologous but also analogous with each other. Continuing, Foster says that, "marginal growth ceases when the main lobes of the lamina have been formed."

If homology and analogy, which would lead towards a clarification of morphological and phylogenetical ambiguities, may be elucidated from a study of ontogenies, we have here a remarkable exhibition of these principles in the ontogeny of the leaf of angiosperms and that of the carpel of *Cananga odorata*, so that we can clearly comprehend the fundamentally similar nature of the two structures without the interpolation of any speculative hypothesis. The analogy of the early maturation of the marginal meristem shows that in the carpel of *Cananga odorata*, laminal differentiation attains normal completion before the inception of the placental ridges, and at the same time negates the possibility of any assumption of "involute margins." The transection of the carpel of *Cananga odorata* presented in Fig. 4 is a true homologue of a nearly mature, adaxially conduplicate foliar appendage, the entire inner surface of the cleft corresponding to the adaxial surface of the foliar lamina.

The placental ridges make their appearance soon after or simultaneously with the cessation of the activity of the marginal meristem. The ridges, which develop from the adaxial laminar surface of the carpel by the activity of the two undifferentiated groups of meristematic cells are, in the beginning, situated more towards the centre of each half-lamina and are far removed from the true margins (Fig. 5). This is exactly similar to the condition encountered in *Degeneria* (Swamy 1949), and is probably true of other primitive, unsealed ranalean megasporophylls. Thus, the

FIGS. 1–6. Transections of the carpel of *Cananga odorata* (Lam.) Hook. f. & Thoms. during successive stages of ontogeny. For explanations see text. 1 × 547; 2 × 540; 3 × 453; 4 × 240; 5 × 270; 6 × 204.

FIGS. 7 & 8. Successive transections of a mature carpel at the time of anthesis, showing the procambial vascular supply to the ovules "given out" from the dorsal trace. × 90.

location, as well as the manner of initiation and differentiation of the placental ridges do not suggest a "marginal" placentation, or an "involution" of the true carpellary margins. On the other hand, these ontogenetic successions clearly indicate that the placentation is laminar, and the actual margins are *not* involved in placentation. While in *Degeneria*, *Drimys*, and other relatively primitive carpels the sterile marginal portion of the lamina beyond the place of origin of the placental ridges attains an extensive development in the form of externally flaring stigmatic surfaces, in *Cananga odorata*, there has been a phylogenetic reduction in the activity of the marginal meristem, and consequently of the flaring stigmatic part.

As the placental ridges continue development, the carpel wall undergoes a corresponding abaxial bulging to inclose the cavity of the carpel (Fig. 6). The abaxially directed placental ridges almost fill the cavity of the carpel. The procambium of the ventral vascular strands differentiate within the lamina, at points far removed from the true margins (Fig. 6). As a result of continued abaxial bulging of the carpel wall with a corresponding widening of the cavity of the carpel, the ventral surfaces of the megasporophyll are brought nearer to each other almost to the point of concrescence (Figs. 6, 7, 9). The ovules differentiate from the rim of the placental ridges.

The developmental changes described above are, however, confined only to the lower, ovule-bearing part of the carpels of *Cananga*. There is very little modification in the upper, stylar and stigmatic regions, where the conduplicate nature remains more or less "set." In these regions, the epidermal cells along the inner surface of the adaxial furrow develop into papillate hairs. A similar differentiation of epidermal hairs takes place also in the ovary cavity around the base of the funicle and in the region of the approximated ventral surfaces of the carpel wall.

It must be emphasized that the ventral surfaces of the carpel do not undergo ontogenetic fusion even during the post-fertilization stages of development. They remain only tightly approximated (Figs. 7–9). On this account, it is possible to open (at least in the pre- and early post-fertilization stages) the carpel along the ventral suture, thereby exposing the ovules on the corresponding halves. As commented by Bailey and Swamy (1951), the erroneous concept of involute margins and of marginal placentation is obviously the result of taking into consideration only the end products of phylogenetic specialization without a study of the series of successively modified ontogenies.

The remarkable nature of vascularization of the ovules in *Cananga odorata* call for special mention as the situation affords additional evidence in favor of the conduplicate concept. The mature carpel of this plant is supplied with two ventral strands and a single median strand (Figs. 7–9). Even though the median strand is the first to differentiate in ontogeny, it remains unbranched even in the mature carpel except for strands which vascularize the ovules. The ventral strands, which differentiate comparatively late in ontogeny, are on the other hand, provided (at maturity) with several branches, all of which extend towards the median strand

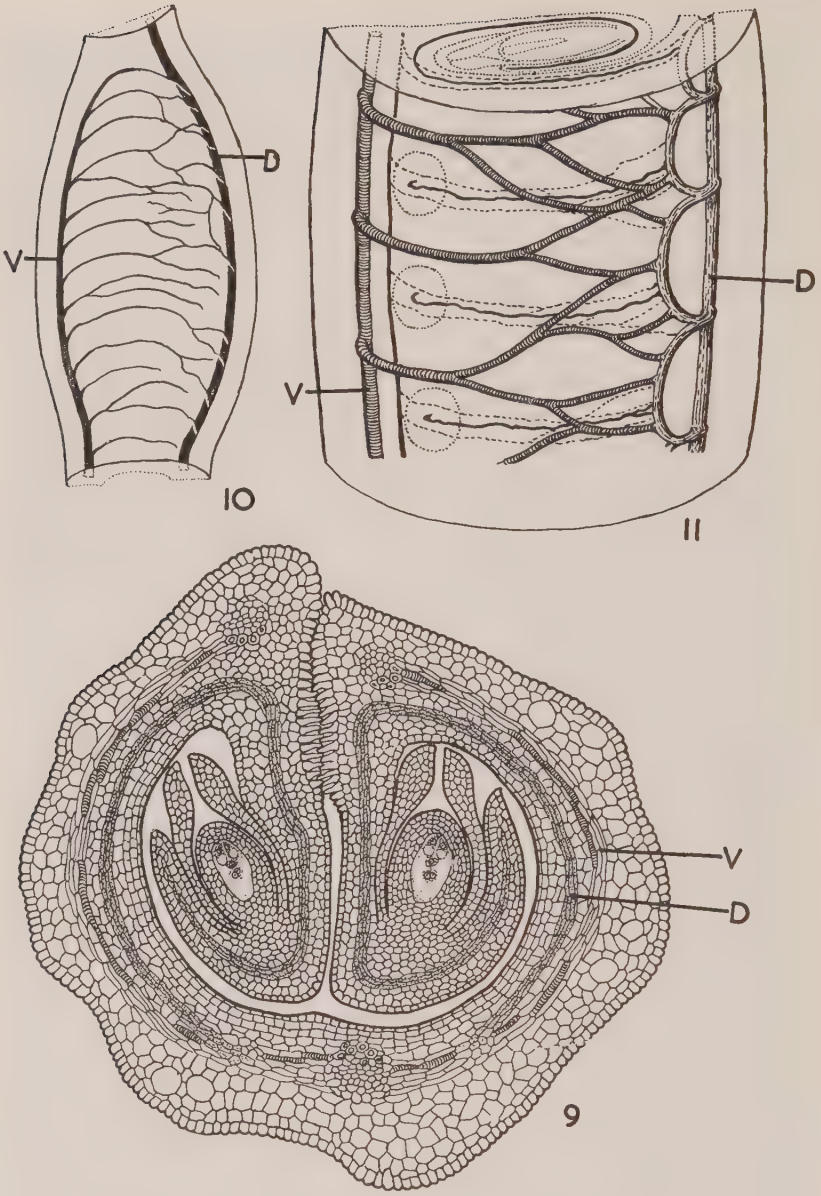

Fig. 9. Semi-diagramatic representation of the transection of a mature carpel. × 180.

Fig. 10. Vasculature of the mature carpel during anthesis as seen in cleared preparations. Style and stigma removed and only one longitudinal half is shown (Semi-diagrammatic).

Fig. 11. Diagrammatic representation of the vasculature of the carpel during early post-fertilization development as seen in cleared preparations. Only a portion of one longitudinal half is shown. The dotted circles indicate the place of insertion of the funicles. D = Dorsal system of vasculature. V = Ventral system of vasculature.

through the corresponding side of the carpel wall. The branches undergo further proliferation and anastomoses, and some of the ultimate endings establish connections with the median strand (Fig. 10). It must be noted, however, that none of these branches belonging to the ventral system is concerned in the vascularization of the ovules.

The vascular supply to the ovules remains procambial in the mature carpel (at the time of anthesis). It is remarkable that they are supplied from branches arising from the median strand, and *not* from the ventral strands, although the latter are situated nearer to the funicles than is the former (Figs. 7–9). Thus, as seen in a transection of the mature carpel, the procambial strand, which consists of three to four cell layers in thickness, extends from the funicle directly to the median strand of the carpel through the corresponding side of the wall, and has no connection with the ventral strand of the respective side (Figs. 7–9). During its course through the carpel wall, the ovular strand lies internal to the ventral system of vasculature (Fig. 9). In the vicinity of the median strand, the ovular trace establishes connection with the anastomoses formed by the short branches of the dorsal system (Fig. 9).

The vascular picture of the mature carpel remains without any profound modifications during early post-fertilization development (Fig. 11). Even after the differentiation of tracheary elements, the ovular strands do not establish connection with those of the ventral system (Fig. 11). Any connection between the two is brought about only very late when the vascular skeleton becomes highly complicated by the development of secondary vasculature in the fruit wall.

The vasculature of the carpel of *Cananga* exhibits an important deviation from other ranalean carpels. In contrast to the condition met with in *Cananga*, it is the dorsal system of vasculature that attains a more extensive development than the ventral system in the mature carpels of *Degeneria*, *Drimys*, and other winteraceous representatives (Bailey and Smith, 1942; Bailey and Nast, 1943; Bailey and Swamy, 1951; Swamy, 1949). The singular nature of vascularization of all the ovules from the dorsal system alone is a unique feature of *Cananga odorata*, and is not known to occur in other ranalean carpels thus far studied. An approach to this condition is, however, seen in *Drimys* and *Degeneria*, where the ovules are vascularized in part by ramifications of the ventral veins, and in part by extensions of the dorsal system of veinlets (Swamy, 1949; Bailey and Swamy, 1951)..

While it is true that vascularization of the ovules by the dorsal system is proof of a laminar placentation, it is interesting that such an anatomical pattern should be retained in the carpels of *Cananga*, which exhibit considerable degree of evolutionary advance in regard to other features. Probably, this situation is yet another remarkable example of the fact that in the *modus operandi* of organic evolution structural changes do not always proceed at a synchronous rate in all the individual features of an organ concerned. Cumulative evidences from comparative morphological studies are becoming increasingly significant and suggest that while an

organ may have undergone structural modifications with regard to certain of the characters, it may remain yet unmodified with regard to other features. In fact, it is the recognition, study and understanding of such "varying segments of salient evolutionary sequences" within the assemblage of extant plants themselves that has recently been of great value in enhancing our knowledge of trends in evolutionary history.

SUMMARY

The early ontogeny of the carpel of *Cananga odorata* is similar to that of a simple angiospermous foliar appendage. A carpel primordium is at first solid and rounded as seen in transections. During development it assumes a roughly triangular outline with a flattened adaxial side. Marginal meristems which function at both corners of the adaxial face bring about the formation of a furrow on the corresponding side, and the two free arms correspond to the lamina of a leaf. The marginal meristem ceases activity at an early stage. Therefore, the laminar margins do not show any evidence of involution. The placental ridges develop from the adaxial surface of the lamina. Just as the ovule-bearing part, the stylar and stigmatic regions of the carpel also exhibit conduplication.

The mature carpel is vascularized by two ventral strands and a median strand. The ventral strands develop a more extensive system of branches than the dorsal. It is remarkable that the ovules are vascularized by branches of the dorsal strand. The ventral strands are not involved in this phenomenon. Such a situation persists even during the early post-fertilization development. The ontogeny of the carpel, the place of origin of the placental ridges, and the unique nature of vasculature of the ovules, are remarkable evidences in favor of the "conduplicate concept" of ranalean carpels. This situation further emphasizes the need for modification of the "Classical View" that looks upon the carpel as possessing involute margins and marginal placentation, and as giving vascular supply to the ovules solely from the marginal (Ventral) vascular strands.

LITERATURE CITED

BAILEY, I. W. AND C. G. NAST. 1943. The comparative morphology of the Winteraceae. II. Carpels. Jour. Arnold Arb. **24:** 472–481.

——— AND A. C. SMITH. 1942. Degeneriaceae, a new family of flowering plants from Fiji. Jour. Arnold Arb. **23:** 356–365.

——— AND B. G. L. SWAMY. 1951. The conduplicate carpel of dicotyledons and its initial trends of specialization. Amer. Jour. Bot. **38:** 373–379.

FOSTER, A. S. 1936. Leaf differentiation in angiosperms. Bot. Rev. **2:** 349–372.

SWAMY, B. G. L. 1949. Further contributions to the morphology of the Degeneriaceae. Jour. Arnold Arb. **30:** 10–38.

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NEW COMBINATIONS IN HYDRANGEA

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The following new combinations, to be used in a monograph of the genus *Hydrangea* (Saxifragaceae), are presented at this time in order to make the names available. Complete synonymy will be included in the forthcoming publication of the monograph.

Hydrangea arborescens L. subsp. **discolor** (Seringe) stat. nov.

Hydrangea arborescens L. var. *discolor* Seringe in DC. Prodr. **4**: 14. 1830.

Hydrangea arborescens L. subsp. **radiata** (Walter) comb. nov.

Hydrangea radiata Walter, Fl. Carol. 251. 1788.

Hydrangea aspera Don subsp. **strigosa** (Rehder) comb. nov.

Hydrangea strigosa Rehder in Sargent, Pl. Wilson. **1**: 31. 1911.

Hydrangea aspera Don subsp. **robusta** (Hooker f. & Thomson) comb. nov.

Hydrangea robusta Hooker f. & Thomson, Jour. Linn. Soc. Lond. Bot. **2**: 76. 1858.

Hydrangea aspera Don subsp. **sargentiana** (Rehder) comb. nov.

Hydrangea sargentiana Rehder in Sargent, Pl. Wilson. **1**: 29. 1911.

Hydrangea anomala Don subsp. **petiolaris** (Siebold & Zuccarini) comb. nov.

Hydrangea petiolaris Siebold & Zuccarini, Fl. Jap. **1**: 108, *t. 54*. 1840.

Hydrangea scandens (L. f.) Seringe subsp. **liukiuensis** (Nakai) comb. nov.

Hydrangea liukiuensis Nakai, Bot. Mag. Tokyo **25**: 63. 1911.

Hydrangea scandens (L. f.) Seringe subsp. **chinensis** (Maximowicz) comb. nov.

Hydrangea chinensis Maximowicz, Mem. Acad. St. Petersb., ser. 7, **10**(16): 7 (Rev. Hydrang. As. Or.). 1867.

Hydrangea scandens (L. f.) Seringe subsp. **kwangtungensis** (Merrill) comb. nov.

Hydrangea kwangtungensis Merrill, Jour. Arnold Arb. **8**: 7. 1927.

Hydrangea macrophylla (Thunberg) Seringe subsp. **stylosa** (Hooker f. & Thomson) comb. nov.

Hydrangea stylosa Hooker f. & Thomson, Jour. Linn. Soc. Lond. Bot. **2**: 75. 1857.

Hydrangea macrophylla (Thunberg) Seringe subsp. **chungii** (Rehder) comb. nov.

Hydrangea chungii Rehder, Jour. Arnold Arb. **12**: 69. 1931.

Hydrangea section **Euhydrangea** subsection **Macrophyllae** subsect. nov.

Flores albi, caerulei, vel carnei; ovarium inferius ad anthesin, ½ superius in fructu, capsula apice conica; stylis connatis usque ad medium vel minus profunde partitis.

TYPE SPECIES: *Hydrangea macrophylla* (Thunberg) Seringe.

THE DIRECTOR'S REPORT

The Arnold Arboretum during the Fiscal Year ended June 30, 1956

By tradition the report of the Director of the Arnold Arboretum is published in the October issue of the Journal of the Arnold Arboretum and of late years has been distributed as well to the Friends of the Arnold Arboretum. The report, therefore, is written at the beginning of the summer, usually after the rush of activities of a busy spring. It is natural that the beauty of the Arboretum grounds during the past few months is foremost in the director's mind as one of the outstanding events of the past year. Spring was late in its arrival at the Arboretum in 1956 and the flowering season was characterized by one of the most unusual mixtures of flowering periods on record for Jamaica Plain. With forsythia and lilacs in nearly full bloom at the same time and with the lingering flowering of magnolias and normal flowering of various species of azalea there were many combinations of color and beauty never before recorded on our grounds. The grounds staff was able during the fall and winter to complete a backlog of pruning made necessary by the hurricanes of recent years, thus bringing the grounds to top condition. With the cooperation of the Boston Park Department in improving the appearance of the walks and roadways, one often heard the public comment, "The Arboretum has never looked as attractive as it does now."

The Staff:

The staff was saddened during the past year by the death of its Director *Emeritus*, Elmer Drew Merrill, on February 25, 1956. Dr. Merrill's long and active career in contribution to the knowledge of the Pacific area vegetation was reviewed in the July issue of the Journal of the Arnold Arboretum. His service to the Arboretum and to botany at Harvard was significant. With his appointment in 1936, he undertook to coordinate or combine, for greater efficiency and economy, the activities of nine separately endowed botanical organizations at Harvard. He was appointed the first "Administrator of Botanical Collections" and was supervisor of the Arnold Arboretum. Under his direction the Arboretum expanded its program of study in Asiatic vegetation and increased both its library and herbarium resources of this area. His own research interests in the Orient allowed him to guide with personal attention the exploration and collections of many young botanists. The outbreak of the second World War prevented the implementation of the plans Merrill had prepared for the union of botanical resources at Harvard and it was only after his retirement that his administrative ideas were carried out. The war effort, however, again demonstrated the practical value of the botanical information inherent in the herbarium collections and library necessary for the study of plants and

Merrill's several books on emergency food plants and the educational and recreational guides to the biology of the Pacific area drew just praise. Dr. Merrill retired as Director of the Arnold Arboretum in 1946 and as Arnold Professor of Botany in 1948, at the age of seventy-two. It was then that he received his first Guggenheim Fellowship, an award usually reserved for younger men, to make possible several trips to European herbaria and a continuation of his studies. Unfortunately, a series of heart attacks limited his activities and led ultimately to his death. Tributes and honors to Elmer Drew Merrill have been received at the Arnold Arboretum from many of the societies and fellowships to which he belonged. He was known around the world, as recent tributes from institutions as far separated as the Academy of Sciences of the Philippines from the Académie des Sciences in Paris will testify.

It is also with regret, but with appreciation for their services, that I announce the retirement and resignation during the fiscal year of Miss Hariklia Yeranian in July of 1955 and Mrs. Beatrix Farrand during the winter months. Miss Yeranian, a mounter of specimens at the Arnold Arboretum for thirty-two years, saw the development of the herbarium to its stature of today. Beatrix Farrand, noted horticulturist and long a friend of the Arnold Arboretum, was appointed consulting landscape architect in 1945 and contributed valuable services in the necessary revamping of the grounds following the unavoidable neglect of the war years. Through her vision the Arboretum has vistas, groupings and patterns of color for all to enjoy on the grounds.

Two botanists were added to the staff of the Arboretum during the past fiscal year to work on special projects supported wholly or in part by special grants. Dr. Robert Bennie Channell, who received his Doctor of Philosophy degree from Duke, joined the staff to work with Dr. Carroll Wood on the vegetation of the southeastern states. This work is supported in part by grants from the National Science Foundation and by the George R. Cooley Fund for work in taxonomy of flowering plants.

Dr. Ding Hou received his doctorate from Washington University in St. Louis, where he worked under Dr. Robert Woodson in preparing a revision of the genus *Celastrus*. Dr. Hou accepted a one-year appointment at the Arboretum to assist on the Flora of China project which has been supported by grants from the China International Foundation.

Honors came to several staff members during the year. Professor I. W. Bailey was elected a foreign member of the Linnaean Society of London and an honorary member of the Indian Botanical Society. Dr. Donald Wyman continued his services as a Trustee of the Massachusetts Horticultural Society and was elected secretary of the American Horticultural Council, succeeding in that office Dr. George Lawrence of the Bailey Hortorium. Dr. Howard was elected to serve a one-year term as one of the Directors of the American Association of Botanical Gardens and Arboretums. Dr. Kobuski was re-elected Assistant Curator of the herbarium of the New England Botanical Club and continued to serve on the council of that organization. Dr. Wood accepted the secretaryship of the Syste-

matic Section, Botanical Society of America in preparation for the meeting of the American Institute of Biological Sciences to be held in Storrs, Connecticut, in 1956.

Members of the staff, both officially and informally, represented the Arboretum at horticultural and botanical functions on both sides of the Atlantic during the past year. Dr. Howard attended the Fourteenth International Horticultural Congress held in the Netherlands. His visit to European gardens will be described later in this report. Dr. Sax and Dr. Wood attended annual meetings of the American Institute of Biological Sciences in East Lansing, Michigan, in September. Dr. Donald Wyman represented the Arboretum at meetings of the American Horticultural Council and the American Association of Botanical Gardens and Arboretums held jointly in Philadelphia. Mr. Coggeshall attended the meeting of the Plant Propagator's Society in Cleveland, where he presented a feature paper on the propagation of Asiatic maples. Dr. Karl Sax was chairman of the opening session of the Brookhaven National Laboratory Genetics Symposium and attended the American Society of Horticultural Sciences Conference on root-stocks held at Monmouth, Maine. He also presented papers at the Northeast Regional Meeting of the American Society of Horticultural Sciences held at the Biological Laboratories in Cambridge during the winter.

The requests for staff members of the Arboretum to speak for meetings of garden clubs and groups interested in the work and resources of the Arboretum and its staff continued to exceed our ability to fulfill. Such extension services must, of necessity, remain an extracurricular activity of the Arboretum staff members. Even so, staff members travelled widely and spoke to many groups on a wide variety of topics. Dr. Howard presented one of the Science Lectures in the winter lecture series at the Fairchild Tropical Garden in Miami, Florida, while en route to Jamaica for field work. On the same trip he spoke to garden clubs in Daytona Beach, Hobe Sound and West Palm Beach and to Harvard Clubs in Jacksonville, Winter Park, Miami and St. Petersburg in Florida and in Birmingham, Alabama. In addition to this schedule, he lectured to other groups in several of the New England States. Dr. Sax and Mr. Coggeshall each took part in the lecture series of the Massachusetts Horticultural Society in Boston. Mr. Coggeshall spoke for the Massachusetts Nurserymen's Short Course, for the Gardeners and Florists Club of Boston and also to the Rhode Island Nurserymen's Association. Dr. Wood described the activities of the Arboretum to Harvard Clubs in Massachusetts and in North Carolina and Dr. Wyman and Mr. Williams lectured on subjects of their specialty to garden clubs in several New England States. The Arboretum is fortunate in being so well represented by capable speakers.

Horticulture:

Again this past year the weather of New England has varied from that expected and so has been an important factor in the growth and maintenance of the plants at the Arboretum. During the summer sustained rainy

FIG. 1. Flooding in the Arnold Arboretum during the heavy summer rains, 1955. Both pictures taken on August 19th.

TOP: Bussey Brook looking towards Walter Street Gate with the water reaching the road.

BOTTOM: Flood waters in the Linden collection near the *Cercidiphyllum* across from the Meadow Road.

periods, especially those associated with hurricane "Diane," produced flooding in many parts of the grounds and caused the Bussey Brook to run high and wash out its retaining walls in several places. The floods themselves did not do serious damage but the saturation of the ground, with accompanying gusty winds, even though low in velocity, caused the loss of several trees which had been weakened in previous seasons by hurricanes. We notice especially the loss of a specimen white oak across from the collection of mountain laurels which leaned for many years towards Bussey Brook. It was under this tree that a memorial service for Charles Sargent was held in 1927. This magnificent oak, which withstood the severe hurricanes of 1938, 1953 and 1954, fell during an eleven-inch rainfall in the summer of 1955 and of course could not be re-established.

The high water table lasted into the fall and winter and the freezing and thawing of the early months of 1956 produced further standing water in parts of the Arboretum. The linden collection, located in a natural low spot along the Meadow Road, appears to have been affected by this standing water and several of the larger trees show signs of considerable damage. In addition, mould became prevalent in the turf of that area and required special treatment.

One of the latest freezes on record occurred on May 25th in Jamaica Plain and was also felt at Weston. This late freeze caused minor damage to the leaves and flowers normally open at that time, but, insofar as is known to the present, will have no lasting effects on the ornamental plantings in Jamaica Plain. The apple crop at Weston, however, is a total loss this year because of the freeze.

The destructive effects of the torrents of water which poured down Bussey Brook, crossing above the road at the rhododendron collections and washing out the retaining walls, have required special consideration. Several of the plantings in the rhododendron collection lost soil from around the roots. Erosion is also evident at the golden larch plantings. As the maintenance of such storm sewers is the responsibility of the Boston Park Department, this condition has been called to their attention and some work was started on replacing the retaining wall during June.

The appearance of the grounds, particularly near the lilac collection, was greatly enhanced this year when the Park Department found it possible to clean out the grass and soil from a portion of the cobblestone gutters which line the roads. This task has been neglected since before the War. The accumulation of silt and the encroachment of grass and weeds made maintenance of the collections difficult, thus detracting from the appearance of the grounds. The workers of the Park Department started at the collection of viburnums and cleared down to the forsythias. The Arboretum crew continued the work to the Forest Hills Gate and also edged all the sidewalks from the Forest Hills Gate to above the lilacs. The Park Department also repaired the macadam sidewalks, improving the appearance and increasing the safety of these paths. Again, neglect and lack of care in recent years had created unsightliness and hazard in the tussock growth of grass in the sidewalk areas.

FIG. 2. The Sargent cherry near the pond at the Forest Hills Gate was badly broken during the hurricanes of 1954 and had to be removed. A large specimen was moved by the Arboretum staff to a more favorable spot on the edge of the same pond.

Special attention has been given to the plantings at the summit of Bussey Hill. Many of these shrub plantings had become overgrown and filled with weed trees. The valueless plants were weeded out of these areas and many of the approaches to the turn-around area were planted in ground covers which will improve the appearance of the area and at the same time demonstrate many of the better ground covers in natural settings, to contrast with the comparative row plantings of Weston.

The collection of rhododendrons has responded so well to the applications of fertilizer and, in particular, to castor pumice applied in the past two years, that additional supplies of this fertilizer were added to the mountain laurel collection and to various plantings of azaleas. The collection of *Rhododendron calendulaceum* bloomed especially well this year, indicating that the treatments given have been correct. The overgrown collection of Ghent hybrid azaleas also received special attention during the fall. The resulting bloom in the spring was spectacular. Both of these collections were outstanding in their excellent natural setting among the oaks.

During the last year the Arboretum was troubled with a severe infestation of rhododendron scale which resisted control with the usual sprays and methods of application. This scale was tentatively identified as one of the Kermes scales which invades the crevices of the bark. The mature scales are extremely difficult to kill. It was recognized that an attack on the hatching scales would be the only satisfactory method of control. Applications of two pounds of 50% wettable DDT and two pounds of 25% malathion wettable powder in 100 gallons of water were made with a power sprayer to allow the spray to run down all the branches and twigs. Applications made on June 20, July 8 and August 1 seemed to give almost complete control of this pernicious pest. The only other disease of consequence in the Arboretum has been the outbreak of fire blight on crab apples and other members of the Rosaceae, but control by the new antibiotics appears to be effective, although expensive at the present time. During the year applications of milky spore disease, under the trade name of "Doom" were made to the lawns and grassy areas within the Arboretum. It is hoped that this attack on the Japanese beetles will reduce their numbers within a few years. In the meantime, spraying with insecticide was continued to counter the ravages of these insects, primarily on members of the Rosaceae.

Among the items of equipment purchased in the fiscal year were a mechanized rotary soil screen to make possible the use of street sweepings and leaves deposited in our dump by the Street Department of the City of Boston. A double disc was purchased to facilitate cultivation in the shrub collection. A new two-ton Chevrolet truck with a dump body and a winch was a needed item to replace an old Army truck purchased in 1948 from Army surplus. A new type of lawn mower with a rotary blade called a "Snappin' Turtle" was obtained to replace the reel-type mower used along the walks and in the shrub and lilac collections. The new machine not only has a reverse drive, making it easier to handle, but will cut taller grass than our older machine.

Two hundred and twenty species and varieties were added to the collec-

tions in a fall and spring planting program. Of these, seventeen appear to be completely new to American gardens and forty-nine additional ones have never been tried at the Arnold Arboretum. The remainder, in some cases, duplicate plants already in our collections, but represent additional clones for trial, while others represent taxa which have been grown at the Arboretum in the past but have died out or have been lost.

Dr. Wyman continued to act as coordinator for a group of American arboreta and botanic gardens by working in conjunction with the Horticultural Crops Research Branch of the U.S. Department of Agriculture in bringing into the United States for trial plants now on the "prohibited list." One hundred and forty-five plants have been introduced and grown for two years at Glen Dale, Maryland, to satisfy the Bureau of Plant Quarantine Regulations. They have now been released to interested arboreta for propagation and distribution. Fifteen taxa were released for the first time this year.

Four plants were propagated and offered for distribution to nurserymen in continuation of the Arboretum's program of making the best ornamental plants available for commercial distribution. Thirty-six nurserymen in the United States, Canada, England and the Netherlands accepted plants under the terms of agreement to propagate from the plants supplied. The origins of the four plants, *Magnolia loebneri* cv. "Merrill," *Crataegus monogyna* var. *inermis*, *Pyracantha coccinea* cv. "Kazan" and *Cornus alba* var. *sibirica*, are of interest. *Magnolia loebneri* is a hybrid species known in Europe since its first production around 1885. The best features of the two parents, *Magnolia stellata* and *M. kobus*, appeared in the hybrid. Unfortunately, the hybrids introduced into the United States did not prove desirable or hardy in the Boston area. The same parents were crossed by Dr. Sax at the Arboretum in 1935 and the most desirable selection from this cross was given the cultivar name honoring Dr. Elmer Merrill. *Magnolia loebneri* cv. "Merrill," therefore, is a new selection of a cross which has long been known. Of a different origin is *Crataegus monogyna* var. *inermis*, an excellent but little known thorn-apple which has been under cultivation at the Arboretum since 1914. The staff felt that this plant should be better known; hence its selection for distribution to cooperating nurserymen. The remaining two plants offered, *Pyracantha coccinea* cv. "Kazan" and *Cornus alba* var. *sibirica* are recent introductions of the Arnold Arboretum from Europe. It is felt that the former, although still under trial, will prove to be more hardy than any other fire thorn. The latter was selected as true to type, for many inferior plants, incorrectly named, are being grown under this name throughout the country. This stock distributed by the Arboretum will assure nurserymen of a re-established standard plant, accurately determined.

In addition to plants which were sent to cooperating nurserymen, the Arboretum has filled many requests for plant materials and plant parts from literally all sections of the world. Requests for materials from the living collections varied from pollen for identification and breeding programs to seeds and propagating material to herbarium specimens and pre-

served or fresh material for scientific study. These requests are filled as time and personnel permit. During the past fiscal year the propagator distributed on request ninety-four shipments of seeds representing three hundred and twenty-two species and varieties. These were sent to eleven countries besides the United States and Canada. In addition, one hundred and fifty-one shipments of four hundred fifty-six species and varieties of whole plants or cuttings and similar parts for propagation were sent to four different countries outside of the United States. Such shipments involve time and often considerable routine labor for preparation and may also be expensive when shipments must be sent by air to insure the materials of safe arrival in living condition. Many of the shipments are offered in exchange and many other gardens and arboreta ship, with or without warning, plants or seeds for trial plantings. Thus, during the past year the Arboretum received both by request and without requests one hundred forty shipments of plant parts, representing five hundred sixteen species and varieties.

During the past year it has been possible to establish a working procedure with several gardens and arboreta in the Southeastern United States and in the Caribbean. Now, when seed shipments are received, sizeable quantities are divided and portions of the seed-lot are shipped to more southern institutions for trial. If seed-lots are small, the plants are started in our greenhouses and the quantity of young plants are divided, a portion to be tried for hardiness in our own area and others to be sent for trial further south. We hope by this method to carry through to maturity many of the species and varieties sent to us for trial which in the past have been frequently lost when the young plants were killed by severe winters. At the same time the chance of a hardy strain surviving the New England climate has not been eliminated.

For our own collections, for distribution and for experimental purposes, the propagator increased by cuttings, grafts and budding 15,516 individual plants, representing four hundred seventy-five species and varieties. As the plants propagated were often in excess of our own needs, many were distributed informally for testing purposes through the educational program. In addition, when circumstances permit, the Arboretum will cooperate with outside organizations for worthwhile purposes. Specimen trees were made available for public plantings at several New England libraries during the past year and in response to a special request the Arboretum was pleased to cooperate with the Boston Art Festival Committee. This Committee wished to make a gift of a tree to the City of Boston for the Boston Public Garden. The director felt that the Public Garden should have the most recent "living fossil," *Metasequoia glyptostroboides,* a plant introduced by the Arnold Arboretum, to complement and accompany the older "living fossils," *Ginkgo biloba*, which are present in the Garden. A large tree of the original introduction fortunately was still available in a nursery plot at Weston. The tree was fourteen feet tall, too large for the Arboretum staff to handle; hence it was moved by a professional arborist at his own expense, during the festival. In spite of the

dry weather and the out-of-season transplanting, our latest observation indicates the operation to be a complete success and the tree is growing well in its new location.

Many of the surplus plants grown at the Arboretum find a place on the grounds around the Harvard University Buildings in Cambridge. Surplus shrubs ranging from three to eight feet high and trees six to ten feet high were selected by the Department of Buildings and Grounds from a list of ninety-two species which we felt were desirable for campus plantings. This distribution of surplus plants was mentioned in the original indenture establishing the Arnold Arboretum. Such plantings not only beautify the Harvard campus, but increase the student interest in horticulture and the proper selection of plant materials for landscape and garden design.

We continued a program of renovation of buildings belonging to the Arboretum in Jamaica Plain and Weston. During the year the Administration Building required repairs to the heating system and received new downspouts of heavy copper, as well as a complete outside painting of all exposed wood surfaces. The new rainspouts were badly needed.

The regular work of labelling and mapping the grounds and the checking of records continued throughout the year. Special characteristics of the plants or unusual responses are noted on the records in the master file. Additional photographs were taken of the grounds, the operations and the plants. These consisted of negatives and prints in monochrome and transparencies in thirty-five millimeter kodachrome and larger ektachrome. Photographs and prints are made available on request and are used in publications by the staff, as in Dr. Wyman's recent book on ground covers. The color transparencies have been reproduced in several national horticultural magazines and several were the bases for the drawings of ornamental shrubs and trees which appeared in Life magazine during the past year. The large sign sponsored by the Boston Envelope Company honoring the Arboretum was based on kodachrome slides in our files.

During the year Dr. Wyman was elected secretary of the American Horticultural Council and as a result the Arnold Arboretum has become the official headquarters and letterhead address for this organization. Dr. Wyman was able to complete and ready for publication his book, Ground Cover Plants.

The Fourteenth International Horticultural Congress was held in Scheveningen, the Netherlands, during August of 1956. Dr. Howard, who attended as representative of the Arnold Arboretum, was also able to visit many other botanical gardens and arboreta in Europe. His trip included visits to the Botanic Garden of the Riksmuseum in Stockholm and the old gardens at Charlottenlund in Sweden. In Denmark he visited the herbarium and the botanic garden, as well as the University gardens in Copenhagen, and made a special trip to northern Denmark to see the private botanic garden of the late Dr. Borgesen and to study some of the government forests in the area. Travelling by airliner made it possible for Dr. Howard to make short visits to the botanic gardens in Hamburg, Berlin, Hanover, Göttingen and Munich in Germany. After arriving in Zürich and visiting the

botanic garden of the University, Dr. Howard was invited to accompany Dr. Däniker, the director of the garden, on a trip across the Alps to Lake Maggiore and the newly-established botanic garden on the island of Brissago. This island garden, a short boat ride from Lucarno, features tropical and subtropical vegetation within sight of snow-capped mountains and glacial streams. His trip continued across northern Italy and across the Alps, this time by train, down the Rhone valley to Lucerne and Geneva, where he visited the botanic gardens in order to study the formal plantings so well done by the Department of Parks in the city of Geneva.

FIG. 3. The first general assembly of the Fourteenth International Horticultural Congress held at Scheveningen, the Netherlands, August 1955. Dr. Howard represented the Arboretum at these meetings.

The Horticultural Congress was held at the sea-side village of Scheveningen, just outside the Hague, which serves as headquarters for many international congresses. Excursions and visits were arranged before and during the Congress for the many visitors from abroad. Delegates and members attending the Congress far exceeded expectations and taxed the limited housing facilities to the utmost. However, the hosts met the situation and conducted an enjoyable and extremely well-executed Congress. Dr. Howard attended the pre-congress sessions of the Committee on Horticultural Nomenclature and Registration and, along with Dr. George Lawrence of the Bailey Hortorium, shared the distinction of being the only American horticulturists in these important sessions. The Committee

was unable to complete its discussions before the Congress convened and therefore held evening meetings during the scheduled program. Dr. Howard served on the subcommittee appointed by the chairman to draw up the resolutions for the Congress as a whole and he also agreed to serve on behalf of the Arnold Arboretum in an effort to compile a directory of privately maintained systematic listings of cultivar names and to report on such a list at the next Congress.

Excursions during the Congress took members to various parts of the Netherlands. Visits to the old arboretum at Boskoop, to Belmonte, the new arboretum, and to the commercial nurseries in the area proved most interesting. Comparisons in size of the collections at the new arboretum made by its director with the collections of the Arnold Arboretum proved embarrassing, as well as amusing. The removal of Dr. Sargent's collection of *Crataegus* from the slopes of Peter's Hill in Jamaica Plain was not known to the director of the Dutch Arboretum. It was a surprise to him to learn that his little Arboretum now contains more species and varieties of both *Crataegus* and *Sorbus* than does the Arnold Arboretum. Exchange of plant materials between gardens and nurseries in the Netherlands and the Arnold Arboretum have been many and frequent in the past and, with an appreciation of the resources of each area, will continue so in the future.

A high point of the Congress came near the close when the entire membership was taken to Amsterdam to attend the Alsmeer flower parade held in the Olympic stadium. This show, based on a theme of sound and color, with floral floats interpreting classic works of music, lasted three hours and was followed by a boat ride through the canals of Amsterdam.

The Congress offered the director an opportunity of meeting many horticulturists from remote sections of the world for the first time and of renewing acquaintances with others. After the close of these meetings Dr. Howard visited London, spending some time at Wisley and Kew and then travelled to Edinburgh to take part in the meeting of the Systematics Society of Scotland held at the Edinburgh Botanic Garden.

The trip was pleasant and profitable. It was obvious that American gardens such as the Arnold Arboretum can never compete in appearance with European gardens where meticulous hand labor is more available and more reasonably priced. The schools for gardening apprentices and students which supply much reasonable labor would not be feasible at the Arboretum. Also obvious was the difference in the consideration of the general public for the plants and plantings generally seen in Europe in contrast to our own experience in New England. Nevertheless, the Arnold Arboretum can be proud of the scope of its collections, the quality of the plants and especially the standards of labelling and accuracy of names in the living collections. In these characteristics, few European gardens even approach the Arnold Arboretum and none equals it.

The experimental work of the Arboretum staff dealing with ornamental plants on the grounds and in the greenhouses continued. Experimental and comparative methods of weed and brush control are always possible and, in fact, necessary to maintain the plantings. Special attention was again given

to control methods for *Cynanchum nigrum* and species of *Convolvulus*. Dr. Wood has under observation selected clones of *Robinia*, the rose acacia, both for basic information of the species relationships of the clones and for their possible ornamental value as individuals and as breeding stock. In the greenhouses Mr. Coggeshall continued his experiments on control of germination of seeds, propagation by cuttings, comparability of stock and scion and evaluation of propagation techniques. The intermittent mist propagation system given to the Arboretum for experimental purposes last year has been established and used for comparative propagation experiments with the plastic "tent" technique and other selected methods. Seeds of *Cotoneaster*, *Viburnum, Chionanthus* and *Hamamelis* have been subjected to tests designed to overcome double dormancy through the use of concentrated sulfuric acid. Seeds of *Laburnum* and *Albizzia* have received treatment with hot water and concentrated sulfuric acid to determine comparative effects of these treatments in germination. A number of *Rhododendron fortunei* hybrids of known rooting capability have been used to test the effects of types of media and wounding practices on the rooting of cuttings. An evaluation has been attempted of a new method of propagation using sphagnum moss and plastic by comparison experiments. Experiments of the compatibility of understocks and the treatments necessary in making successful grafts have been conducted with *Pinus* and *Picea* species. After one run was completed a letter was received from Australia asking for exactly the information which that experiment was designed to test. Thus by coincidence the Arboretum was able to supply new experimental data. A number of experiments are in progress to determine the effects which different temperatures, maintained for differing lengths of time, have upon the germination of such tree seeds as *Acer*, *Carpinus*, *Quercus*, *Magnolia*, *Cornus* and *Pseudolarix*. Many of the experiments mentioned are designed to provide the answer to problems long facing the Arboretum and the commercial nurserymen. Other experiments are designed to supply more scientific answers as to why plant materials must be handled as they are to respond as desired.

Finally, mention should be made of a development which will affect both the appearance and the problems of maintenance of the Arnold Arboretum in the future. During the year the City of Boston sold the land known as Joyce Kilmer Park, which is at the junction of Walter and Center Streets. This was deeded directly to the City of Boston and has never been a part of the Arboretum. This piece of wooded land is across from the conifer collection on Walter Street and adjoins the Weld-Walter Street tract of the Arboretum. The Park was sold to the trustees of the Dorchester Home for the Aged and, although the sale was protested by residents of the area, the sale was approved by the Supreme Judicial Court of Massachusetts. The trustees plan to erect on this site a large building tentatively known as the Hebrew Home for the Aged in West Roxbury. The large building will occupy most of the space available in the plot. As construction proceeds in the next year the traffic problem will be accentuated and when completed the service traffic and visitors to the Home will present additional

problems to be faced by the Arboretum staff. It is hoped that this building and its surrounding area can be landscaped so that it does not clash with the natural beauty of the adjacent Arboretum property. The Director of the Arboretum plans to remain in touch with the contractors and the trustees to work out mutual problems which will arise due to this significant change along Centre Street.

The Case Estates:

The horticultural work of the Case Estates in Weston continued without interruption during the year. Damage from floods, windstorms and frost was minor, excepting only the loss of the experimental apple crop due to a late May frost during the flowering period. Several of the buildings on the grounds were given additional attention during the year and one large house and adjacent land, left for the use of Mrs. Theodore Chandler by the will of Miss Marion Roby Case, reverted to the Arboretum when vacated by Mrs. Chandler in February of 1956. With the approval of the Corporation, this house is currently being renovated and will be occupied by the Director of the Arboretum in the fall.

The spring season was very slow in developing at Weston and the open house scheduled on the grounds for May 5th did not show the plants and plantings to the same advantage as did the comparable date of the year before. However, with excellent publicity, including location maps and directions published in the Sunday papers, the attendance was high despite inclement weather. Special attention was called by the newspapers and by an issue of Arnoldia to the collection of street trees and other small ornamental trees which have been established now for five years. This collection is located to the rear of the ground cover plots along the road to the town swimming pool and draws nearly as many visitors annually as does the better known ground cover display plot.

Some display planting of crab apples was done in the open field across from the Weston High School and one new area near the barn was developed for the collection of *Robinia* clones under study by Dr. Wood.

Education Program:

The informal education program of classes for adults held at the Arboretum was continued in two semester sessions during the past year. The interest in these courses remained high and the classes probably have the highest perfect attendance ratio of any education program in Boston.

During the fall the following classes were offered by Arboretum staff members: Basic Botany for the Home Gardener, Dr. Wood; Fall Field Class, Dr. Wyman; Plant Propagation I, Mr. Coggeshall; and Principles and Practice of Plant Identification, Dr. Howard. Mr. Coggeshall's classes in plant propagation proved so popular that three sessions were offered again. The subject matter was divided between fall and spring so that topics for practice and immediate use could be taught at the appropriate time. Dr. Howard's class was new to the program and was designed to familiarize students with the use of keys, manuals and descriptions of

cultivated plants and to recognize the larger groups of cultivated plants by the morphological characters that define and distinguish them.

Two new classes were added to the spring program of education classes. Mr. Albert C. Burrage, well known to New England horticulturists for his work with economic horticulture of garden vegetables, offered a delightfully informative course in Gardening with Vegetables. The course was highlighted by the instructor's pleasing personality as well as by his prejudices not only for good vegetables but for proper methods of preparation for the table. The course succeeded in tempting the palate as well as the mind. Dr. Karl Sax, of the Arboretum staff, offered a class in Plant Breeding which devoted several evening sessions to the genetic and morphological principles behind the practice of plant breeding and concluded with class meetings on the grounds where crosses were made of standard parentages and several others experimental in nature.

Mr. Coggeshall continued his classes in plant propagation with the second part of the course in the spring. Dr. Howard continued his class in plant identification as an advanced session working with the same group in field practice in late afternoon and evening sessions on the grounds of the Arboretum. A fifth class was Dr. Wyman's ever-popular spring field class, which was well attended.

In addition to the formal classes described, the staff joined in other types of instruction. During the spring, guided tours of the grounds were offered to any group bringing a minimum of twenty-five persons and scheduling the trip in advance. Garden clubs in particular are familiar with this service and use these trips as programs and sources of information. Few such trips end without a concentrated question-session.

The staff also cooperated with the Massachusetts Horticultural Society in presenting their annual Field Day at the Arnold Arboretum on Saturday, May 19th. Postcards to all members of the Horticultural Society announced the morning session which would consist of guided tours in sightseeing buses equipped with amplifiers to aid the guide in presenting his talk. The attendance was more than expected and the four buses were filled before the scheduled departure time, requiring additional guides for those who had to tour the grounds in their own cars.

This week would normally have seen the lilac collection at its peak and an open house on the Arboretum grounds was scheduled for the following Sunday, May 20th. However, the flowering season was delayed and crab apples, forsythia, magnolias and miscellaneous shrubs supplied the bloom then deficient in the lilacs. Staff members were stationed at strategic places throughout the Arboretum to give directions and to answer questions. It is of interest to note that on the afternoon of the open house the periphery of the Arboretum was completely outlined with parked cars.

Among the groups of visitors to the Arboretum was a study group of horticulturists and nurserymen from Europe. This group of well-known students of ornamental plants included seventeen Germans, one Austrian and one Swiss, with an American specialist as guide and interpreter. The staff was pleased to have these men visit the collections in Jamaica Plain

and regretted only that the close scheduling of their trip made their visit here of short duration.

One of the highlights of the year was the venture of the Arboretum staff into education by television. During the slack summer months the staff was invited to present a series of experimental programs on WGBH-TV Channel 2. The time was selected so that it did not conflict with important network shows and so that the staff of the television station could work closely with the novices in this field from the Arboretum staff. During July and August the Arnold Arboretum presented four weekly hour-long programs entitled "Notes from the Arnold Arboretum," prepared and presented by Mr. Coggeshall, Dr. Howard, Dr. Wood and Dr. Wyman. The staff was in agreement as to the excellence of the medium for presenting information about plants and the fine cooperation received from the studio technicians. However, each program required such a major effort in preparation that with the regular work program before the staff we reluctantly decided against further regular programs. Mr. Coggeshall, Dr. Wyman and Dr. Howard appeared, however, on feature programs or as guests on other programs such as "Discovery" and "Within Your Reach" during the winter and spring seasons. The staff individually and collectively received commendation for the programs and in turn extended their thanks to the cameramen and directors who presented plants in close-ups on television screens to the satisfaction and delight of all. The staff attempts to cooperate as fully as possible with the educational television station and kodachrome slides from the Arboretum collection appear regularly as background scenes for programs, while specimens and plant materials from the Arboretum collections have illustrated many other television programs.

Exhibits and Displays:

For the past several years the Arnold Arboretum has had an exhibit at the spring flower show of the Massachusetts Horticultural Society. During the past year considerable time and effort went into the preparation of an exhibit demonstrating methods of increasing plants. The exhibit on plant propagation covering 1200 square feet of floor space and developed under the direction of Dr. Wyman, Mr. Coggeshall, Mr. Williams and Mr. Howard, was an outstanding exhibit, which again won for the Arboretum a First Prize and a Gold Medal. One of the material aids the Arboretum received in preparing this exhibit was the use of a lean-to type of greenhouse lent through the courtesy of the New England Greenhouse Company, Inc., of Hanover, Massachusetts.

In the exhibit room at the Administration Building in Jamaica Plain the staff offered the annual show of Christmas plants and Christmas greens. In addition to the more common evergreens, the show displayed a collection of dried plant materials bought in advance from the florist markets in Boston. The correct botanical determination of these plants and some information about them was supplied on labels. An outstanding feature of the exhibit, however, was the wreaths and decorations made of dried fruits

FIG. 4. The Arboretum exhibit at the Spring Flower Show featured methods and materials for plant propagation. Designed and executed by Dr. Wyman, Mr. Coggeshall and Mr. Williams, the exhibit won a first prize and a gold medal.

FIG. 5. The Arboretum proudly acknowledges the salute of the Boston Envelope Company through this colorful reproduction of the Forest Hills Gate and the background plantings of cherries. This billboard along U.S. Highway No. 1 has brought many visitors and inquiries to the Arnold Arboretum.

and cones by Mrs. Donald Wyman. It is hoped to utilize the experience and materials of this portion of the exhibit in an issue of Arnoldia for the next Christmas season. A Christmas tree decorated with horticultural ornaments served as the focal point of this seasonal exhibit.

The open houses held at the Case Estates and at Jamaica Plain have been referred to elsewhere. As part of the Commencement Week activities, the staff held open house for members of the twenty-fifth reunion class in scheduling tours and demonstrations in the Harvard University Herbarium in Cambridge.

During the spring the Arboretum was honored with a colorful billboard display along U.S. Route 1. On a sign sponsored by the Boston Envelope Company and under the title, "The Boston Envelope Company salutes the Arnold Arboretum, America's Greatest Garden," there appeared a colorful reproduction of the Forest Hills Gate and the cherry and apple collections inside. As the sign is located at the junction of the Jamaicaway and Brookline Avenue and is illuminated at night, it drew many phone calls and sent additional visitors to the grounds this spring.

Library:

The librarian, Mrs. Lazella Schwarten, and her staff of regular and temporary help were active during the year in the organization and integration of the books housed in the Harvard University Herbarium Building. Work was divided between much-needed physical care of the bindings, changes in cataloguing and actual integration and was carried on in addition to regular services to staff, students and visitors. The air-conditioned and filtered environment has made easier the care of the library volumes. Thus bindings treated or replaced during the year show better retention of quality than ever before.

The integration and cataloguing work of the year concerned primarily the volumes of periodicals. Individual volumes and sets were compared and selected on the basis of condition, origin as gifts or autographed copies, as well as for annotations and usefulness. Complete active sets are now maintained and the duplicates are being held in reserve. The final selection of sets for current use required changes in cataloguing and listings on the volumes and in the main catalogue, the shelf-list cards and the Kardex guide. Lists are also maintained of the reserve volumes. The majority of periodicals are now shelved in one section of the stacks and as work proceeds on the monograph collections and some further shifting is done, the remaining periodicals will be placed in a planned sequence.

With the completion of work on the periodicals, efforts were directed to an examination of the monograph collection. It is planned to integrate and consolidate this collection from the Gray Herbarium and the Arnold Arboretum and the duplicates are to be shelved in the herbarium adjacent to the appropriate family. The monographs will be numbered according to the Dalla Torre and Harms system of Genera Siphonogarum with the Arnold Arboretum supplementary listings and the authors' numbers according to Cutter. This task was about seventy percent complete at the end of the fiscal year.

Changes were made in the section shelving of horticultural books housed in the Administration Building in Jamaica Plain. Portions of the library were shifted to the second floor along with the back numbers of periodicals to allow room for expansion in the main library room. The system of arrangement was changed, involving a complete shift of nearly all books in the library, but resulting in a more workable organization for those visitors not thoroughly familiar with the scientific classification of categories of books.

During the year three hundred books were added to the library, including forty-three specially selected books to complement the horticultural holdings. The total accessioned bound volumes is now 49,509. Pamphlets received and added to the library total two hundred eighteen numbers, making a grand total of 15,968. Five hundred catalogue cards were added to the main file, eight hundred shelf cards were prepared and one thousand cards were added to the Gray Herbarium species index.

Requests for books on inter-library loan continued high, numbering one

hundred thirty-six individual shipments during the year to all parts of the country. The librarian continues to assist where possible in supplying photocopies or microfilm reproductions. If the request is reasonable, the librarian often checks a reference or verifies a page or date in preference to sending a book on loan. Such services characterize and are a credit to our librarian.

During the year Mrs. Schwarten compiled six numbers of the Index to American Botanical Literature which is published in the Bulletin of the Torrey Botanical Club.

Dr. Frans Verdoorn, Research associate, gave most of his time to the preparation of a bibliographic guide to biohistory (the historical and other humanistic aspects of biology and medicine) with some special reference to botany and horticulture. Work on his biographical card index of plant scientists (Index Botanicorum), as well as the gathering of data for his annotated bibliographies on the history of botanic gardens and the Linnaean period was continued along the same lines as during previous years.

Herbarium:

The plans described in previous reports for the integration of the herbarium collections moved to Cambridge and housed in the Harvard University Herbarium were the basis for the work of most of the herbarium staff during the past year. The curator, Dr. Kobuski, directed the progress of the integration and by the end of the year considerable and very satisfactory progress had been made in placing the combined herbaria in first-class condition. During the past year the families of plants represented in the collections of the Gray Herbarium and the Arnold Arboretum which were in proximate arrangement received further adjustments. Two major steps are involved in the handling of each family. In the first step the component genera are placed in sequence and in the second step actual integration at the species or sub-species level is accomplished. Each of these moves may involve considerable work, but in small families both steps can often be accomplished in one operation. Old genus covers are replaced. New generic boards are prepared. Type or authentic specimens are separated. In large families such as the Leguminosae and Rosaceae, even the first step can be complicated and time-consuming. When both the Gray Herbarium and the Arnold Arboretum followed the same generic order and divisions, the task was mainly a physical one of shifting several thousand compartments of specimens. Where different generic order was used or where different generic concepts were recognized, the consistent organization of genera in successive order required careful planning and execution. The decisions to recognize segregate genera or where to place in sequence recently described genera were made after staff consultation so that all staff members taking part in the move were aware of the location and the treatments to be followed. A test case involved the family Verbenaceae, where all available staff members of both institutions, twelve in number, worked on one family at the same time to do complete integration. More

recent practice has been to work in teams of two individuals on the generic integration and as individuals on the species integration. Two workers, therefore, were able to shift and rearrange the genera of the Leguminosae with little confusion and little wasted effort after the initial decisions of generic limits were made and the work planned.

Integration within the genus involves the arrangement of species and subspecific units, the writing of new covers, the geographic arrangement and segregations and the selection and separation of type material. Type or authentic specimens are being placed at the end of the genus or generic geographic unit; e.g., Am. Bor., Ind. Occ., etc., and indication that the type has been removed is made in the species arrangement. Types are being placed in individual species folders for the first time.

Unidentified materials in the herbaria are placed where possible with the genus and the proper geographic unit. Material identified only to family is sorted geographically and filed at the end of the family. The arrangement of geographic areas for the Eastern Hemisphere is that followed by the Arnold Arboretum herbarium and the arrangement for areas of the Western Hemisphere (and particularly the United States) is that used by the Gray Herbarium. At the end of the year the rearrangement of over one hundred families was under way or was completed.

The fruit and seed collection and the photograph and negative collection received additional work during the year. Two college students were employed during the summer to continue the task of arranging the negatives and prints of the type and authentic specimens represented in our herbarium or photographed by staff members elsewhere. The fruit and seed collections were placed in boxes, rather than bottles, and are to be arranged in a system comparable to that used in the herbarium. The boxes of specimens will be stored in special trays and units on the first floor of the building where these collections will be equally available for use by the taxonomists of living plants and the students of the fossil seeds and fruits of paleobotany.

Work on the herbarium of cultivated plants has been limited to checking the coverage of the herbarium in relation to Rehder's Manual and other handbooks of cultivated plants and to mark and separate types of cultivated taxa and cultivars.

During the past year 6060 specimens were mounted and added to the herbarium, bringing the total accession count to 687,807 specimens in the Arnold Arboretum.

The herbarium of the Arnold Arboretum received during the year 19,850 specimens by gift, purchase or subsidy, and exchange. The vast majority of these, 16,599, represented the flora of Malaysia and Asia and 6056 of these were purchased by residual commitments. During the year the Arboretum sent out in continuation of exchange 23,460 specimens, of which nearly all went to herbaria and botanical gardens in Europe and Asia.

One of the major services which the Arboretum staff renders to the botanical and horticultural fields of research is the loaning of specimens from our herbarium. The large number of types and authentic specimens

in our herbarium indicates both the excellence of the collections and the activity of the staff members of the organization who have described new plants and placed in our herbarium the type specimen of the new unit. During the year the Arboretum received requests for the use of its material from forty-eight institutions in twelve different countries. Because of international or internal local disturbances and postal regulations, it was not possible to fill all of these requests. In total, eighty-seven loans were shipped out to forty-six institutions, half of them in the United States. The loans varied in size from single sheets to loans of 1498 and 1674 specimens. A total of over 14,000 specimens was sent out for the use and study of other students of plants.

The research activities of the herbarium staff were reduced again this year as the members devoted the majority of their time to work in the herbarium.

Dr. Howard worked on his collections of plants associated with bauxite soils from Jamaica and continued his studies of the genus *Coccoloba* in the West Indies. With the assistance of a technician, Miss Kathryn Greer, his research on the vascular structure of the petiole was expanded to include more tropical families and genera and involved some material from herbaria. Dr. Arthur Eames generously supplied for this study a large number of rare or unusual leaf forms, largely of the Proteaceae, from his collections of Australian plants.

Dr. Wood worked actively with the organization of a project on the flora of the Southeastern States. Along with Dr. Reed C. Rollins, director of the Gray Herbarium, he received support for this work through a three-year grant from the National Science Foundation. Surveys of bibliographies and indices are being made to classify recent literature references dealing with plants found in that area. Dr. Wood has continued his interest in the genera *Robinia* and *Drosera*, utilizing techniques of cytology and taxonomy in his study of each genus.

Dr. Channell, who has been working with Dr. Wood on the flora of the southeastern states, made a special study of the genus *Rynchospora*, as well as devoting a portion of his time to a completion of studies in progress of *Marshallia*.

Although much of his time is given to his regular work as editor of the Journal of the Arnold Arboretum and curator of the herbarium, Dr. Kobuski was able to devote a little time to the Theaceae, a family of his specialty.

Dr. Perry has accepted responsibilities for many phases of the work in the herbarium and was able to complete the preparation of labels for the collections made by L. J. Brass on the Fourth Archbold Expedition to New Guinea.

Mr. Canoso's work as curatorial assistant has been essential in the smooth functioning of the organization. During the year many collections have been received and accessioned. A major effort was the distribution of duplicate specimens on hand which had to be separated, packed and mailed.

The herbaria and the libraries have been used by the botanists working under the special grants for the Flora of China project. During the year Dr. Hu completed for publication a treatment of the Malvaceae and worked on an enumeration of the Compositae and the Orchidaceae of China. Dr. Liu worked on a monographic revision of the Pontederiaceae and the Stemonaceae for China and Dr. Hou completed revisions of the Palmae, Xyridaceae and Flagellariaceae for the same area.

Dr. Ivan Johnston continued his work on the Boraginaceae in Jamaica Plain and made one trip to Panama during the fall. During the spring semester Dr. Johnston was absent on sabbatical leave, dividing his time between Panama and the New York Botanical Garden.

Comparative Morphology:

Professor I. W. Bailey, Professor of Plant Anatomy *Emeritus*, has served voluntarily as the curator of the wood and pollen collection following his retirement. His efforts in arranging these collections and servicing requests for materials from the collections materially assisted the herbarium staff. Professor Bailey continues his anatomical studies and during the year completed several papers which will be published in the coming issues of the Journal of the Arnold Arboretum.

Several additions were made to the wood collection in the past year. The largest gift was a collection of wood samples from the forestry laboratory of British North Borneo. During the year Mr. Sherwin Carlquist, a National Science Foundation Fellow, studied the materials of the Compositae in the herbarium and the wood collection. Mr. Chen continued his interests in the anatomy of the Sapotaceae and utilized these collections and Dr. Abraham Fahn, visiting scholar from Hebrew University, Jerusalem, Israel, based his investigations on the Arnold Arboretum wood collections.

Cytogenetics:

Dr. Karl Sax, his assistants and students have reported the following contributions in the field of cytogenetics. It has been determined that the Sargent crab apple, *Malus sargentii* and its variety *rosea*, are facultatively apomictic. Some hybrids, however, have been obtained by crossing these plants with both ornamental and horticultural varieties of apple. The resulting hybrids are largely apomictic, suggesting that apomixis is a dominant character, at least in the hybrid swarms. If this is true, it should be possible to produce new varieties, both ornamental and economic in character, which can be reproduced from seed. Such work in selection continues.

Earlier interest in the species and varieties of lilacs has continued as crosses are made between *Syringa vulgaris* and *S. laciniata* and between *S. laciniata* and *S. pinnatifolia*. Both crosses have produced hybrids which are sterile. The sterility is apparently due to failure of the chromosomes to pair at meiosis. One possible method of overcoming this sterility barrier would be to increase the chromosome number and the production of arti-

ficial polyploids is being attempted with the use of colchicine. One induced tetraploid of *Syringa vulgaris* has been produced and has flowered, but so far has failed to set seed when crossed with other clones.

The use of bark inversions to alter the shape and flowering or fruiting characteristics of ornamental and economic trees remains a portion of the research interests of Dr. Sax. The antiquity of this field of research was the subject of an interesting article by Dr. Sax which appeared in the National Horticultural Magazine and was entitled, "What is New in Plant Propagation?" The technique of bark inversion has demonstrated that earlier flowering can be induced by inverting a ring of bark or by tying a knot in the stem of young plants of clonal vegetative propagated varieties. The techniques do not induce earlier flowering in seedlings and as yet no way has been found to shorten the juvenile stage of seedling trees.

Additional grants have been awarded to Dr. Sax by the Atomic Energy Commission to support research in basic investigations of chromosomal structure and behavior. A study of X-ray-induced chromosome aberrations financed by these grants has indicated that the chromosomes become bipartite a full generation before the daughter chromosomes divide. Dr. Sax has also worked in collaboration with the scientists and directors of the Gamma-radiation field at the Brookhaven National Laboratories. The ornamental plants from the Arnold Arboretum which have been grown in this radiation field have not shown as yet any recognizable mutations.

Instruction:

No regularly scheduled classes were offered by staff members during the year, although several took part in seminars and presented lectures for students in areas of their specialties. Two of Dr. Sax's former students completed their theses which were submitted and approved. On the basis of their work Dexter Sampson, now in the Department of Horticulture of the Ottawa Experimental Farm in Ottawa, Canada, and Gweneth Carson, currently a cytologist at the University of California, were awarded the degree of Doctor of Philosophy. Dr. Sax supervised the work of Mr. Claude Brown on bark regeneration and of Frank Santamour who is working on polyploidy in *Populus*. Mr. Tchang Bok Lee, a UNKRA fellow from Korea, continued his graduate work under the guidance of Dr. Howard and instigated during the spring work in hybridization of Korean and North American oaks in the Arboretum collection.

In the regularly scheduled seminars held at the Harvard University Herbarium, the Arboretum staff members contributed several programs. During the spring semester Dr. Wood talked about the "International Rules of Botanical Nomenclature" and was assisted by Dr. Perry; Dr. Howard spoke on the problems and practices of "Nomenclature of Cultivated Plants" and Dr. Kobuski and Dr. Hu reviewed the status of published and unpublished floras for the Eastern Hemisphere.

During the fall semester the seminar was devoted to a consideration of the vegetation of the southeastern states and the associated problems involved in a study of this area. Dr. Wood discussed the geology and geog-

raphy of the area, while Dr. Channell and Dr. Howard discussed two aspects of the vegetational relationships in the area. Dr. Hou also took part in this seminar series and reported on his work with *Celastrus* as an example of methods of study and vegetational relationships.

Travel and Exploration:

The Arboretum continued the policy of supporting its own staff members and other reliable collectors in field work and botanical exploration and collecting. A grant from the American Association for the Advancement of Science, through the American Academy of Arts and Sciences, enabled Dr. Wood to continue a study of the sundews in the Gaspé region of Canada and in northern Michigan. During the spring Dr. Wood collected additional woody materials for trial and study in the southeastern United States. Miss Kathryn Greer, assistant to Dr. Howard, collected morphological materials for anatomical studies in Cuba by means of special funds awarded to Dr. Howard by the American Philosophical Society. Dr. Howard made two short trips to Jamaica to further his study of the vegetation on bauxite soils and the replacement of vegetation on mined-out bauxite pits. During one trip he was able to join botanists from the Institute of Jamaica in an exploratory trip into the John Crow mountains at the eastern end of the island. This mountain range represents the largest and perhaps the most difficult unexplored area left in Jamaica. The goal of this exploration party was to locate a possible site for a base camp having reliable sources of water for further biological exploration of this important mountain chain. Such an area was located and it is hoped that the camp site can be developed for use by naturalists during the next few years.

Dr. Ivan Johnston made one collecting trip to Panama on contract with the U.S. Army Engineers during the fall and did extended work in the same area during a sabbatical leave of absence in the spring semester. His botanical collections from this rain forest will supplement those he made on San José Island of Panama during the war years.

During the spring the Fifth Archbold Expedition, under the direction of Mr. Leonard J. Brass, left for field work in New Guinea. The staff of the Arboretum, under Dr. Merrill's directorship, assumed full responsibility for the identification of the botanical materials from the second, third and fourth expeditions. However, since identifications for the botanical collections of the fourth expedition are not yet completed, the Arboretum agreed only to assist financially this fifth expedition in exchange for one of the early sets of materials.

Gifts and Grants:

The annual appeal to the Friends of the Arnold Arboretum was issued during the spring of the year and the generous gifts indicated the enthusiastic support of the public. The director and his staff are grateful for the gifts from the Friends which are unrestricted and used for horticultural work on the grounds and in our laboratories. During the past year

such gifts made possible a research assistant in the field of cytogenetics, additional help in the greenhouses for plant propagation and labor on the grounds to assist in cleaning and trimming along the paths and roads. Special gifts were also received from Friends for the support of collecting plant specimens and for the publication of writings by staff members.

Again during this year the largest single gift was received from the trustees of the China International Foundation for the support of work on the Flora of China carried on by Drs. Hu, Liu and Hou. Dr. Sax received additional grants from the Atomic Energy Commission for the support of his research and Dr. Howard received a grant from the American Philosophical Society to continue his investigations on the vascular structure of the petiole of higher plants. An additional non-departmental gift from Mr. George R. Cooley for taxonomic work at the joint discretion of Drs. Rollins and Howard was used to support field work and research on the vegetation of the southeastern United States.

We particularly appreciate the kindness of Mrs. Oakes Ames in giving permission to have reproduced her drawing of *Davidia involucrata*. Copies of this excellent print, suitable for framing, have been sent to the Friends of the Arnold Arboretum in acknowledgment of their gifts.

Gifts in kind were numerous and equally appreciated. Gift volumes for the library were received from several sources and included a fine set of Louden's Botanical Encyclopedia of 1854 in excellent bindings presented by Mrs. Frederic Goodwin. The Arboretum received many gifts of plant materials from organizations with which we regularly trade material and information and in addition received noteworthy gifts of material from individuals. Among these latter were cuttings of dogwood received from Miss Harriet R. Halloway, nine scions of tree peonies, originations of Dr. A. P. Saunders, from Miss Silvia Saunders and a group of seven rare evergreens from Mr. Robert E. More.

Publications:

Special attention should be directed to the publications of the staff which have appeared during the past year. Mrs. Susan D. McKelvey, research associate of the Arnold Arboretum and long a member of the Committee to Visit the Arnold Arboretum, completed the work on the proofs of her latest book and saw the first copy issued on March 26, 1956. The book is entitled "Botanical Exploration of the Trans-Mississippi West 1790–1850" and represents long and meticulous research in checking the routes and the botanical collections of the men of science who assisted in opening up the West. Mrs. McKelvey's book contains several excellent maps drawn by Dr. Erwin Raisz. It was published by the Arnold Arboretum and was printed by the Anthoensen Press of Portland, Maine.

Dr. Sax's book entitled "Standing Room Only" was published by the Beacon Press during the year and has been widely reviewed and discussed as a continuing contribution to demographic study.

In March the Macmillan Company issued Dr. Donald Wyman's latest book, "Ground Cover Plants." This book contains 175 pages, is profusely

illustrated and is unique as a record of experience in growing ground cover plants. Also during the year the revised edition of "Crab Apples for America" was published by the American Association of Botanical Gardens and Arboretums. Dr. Wyman was chairman of the committee which compiled the data and was responsible for its publication.

Three issues of the Journal of the Arnold Arboretum were published under the editorship of Dr. C. E. Kobuski. The fourth number of this magazine, which is normally a quarterly, was issued as a double number dedicated to Professor I. W. Bailey during the previous fiscal year. Twelve numbers of Arnoldia were published and issued as seven units, two of which were combined numbers. These were "Christmas Plants for the Boston Area" and the Arboretum's "Spring Planting Notes."

A sample treatment of the Malvaceae was issued on behalf of the Flora of China project. This monographic treatment of the family was written by Dr. Hu and printed by the Tudor Press. In 1953 Dr. Hu was awarded first prize in a Project Suggestion Contest sponsored by the Continental Development Foundation. The problems of preparing a flora of China was the subject of Dr. Hu's essay and the suggestion was considered by the committee to be worthy of further support. With grants from the China International Foundation, work was begun as proposed in the essay, using the library and herbarium resources of the Arnold Arboretum to compile in card catalogue form data on the occurrence, distribution and publication of vascular flowering plants of China. This card catalogue represents the most complete and up-to-date catalogue of vegetational records for the Asiatic mainland and will serve as the basis for future work in forestry, horticulture, floristics and agriculture. The catalogue is available for the use of all qualified visitors to the Arboretum and requests for information from other areas will be filled by photocopy or typescript at cost. To demonstrate the type of work which can be done using these cards and as a possible format for future publications towards a flora of China, Dr. Hu prepared the recently published treatment of the Malvaceae. It is hoped that other botanists will utilize the card resources made possible by the generosity of the trustees of the China International Foundation and that additional family treatments can be published as manuscript and funds are available.

Bibliography of the Published Writings of the Staff and Students July 1, 1955–June 30, 1956

Coggeshall, Roger G. Forcing woody plants for flower show bloom. Am. Nurseryman **103**[2]: 7, 8, 62, 63. 1956.

——— Increasing plants in home gardens. Horticulture **34**: 279–282. 1956.

——— Polyethylene plastic — Its use for the propagation of holly. Am. Nurseryman **102**[11]: 12, 13, 80–83. 1955.

Hou, Ding. A revision of the genus Celastrus. Ann. Mo. Bot. Gard. **42**: 215–302. 1955.

Howard, Richard A. The Director's Report. The Arnold Arboretum during the fiscal year ended June 30, 1955. Jour. Arnold Arb. **36**: 403–430. 1955.

HOWARD, RICHARD A. The International registration of cultivar names. Am. Nurseryman **103**[11]: 62, 63. 1956.

——— Museum for living plants. Horticulture **36**: 347–349, illust. 1956.

——— Notes from the International Horticultural Congress. Newsletter Am. Assoc. Bot. Gardens & Arboretums **25**: 11–16. 1956.

——— & CARROLL E. WOOD, JR. Christmas plants in the Boston area. Arnoldia **15**: 61–84, *pl. 11–14*. 1955.

HU, SHIU-YING. Flora of China. Family 153 Malvaceae. 1–80, *pl. 1–24*. 1955.

——— Malva — A herb of high nutritive value. Herbarist **22**: 22–30, *pl. 1, 2*. 1956.

——— A monograph of the genus Philadelphus. Jour. Arnold Arb. **36**: 325–368. 1955; **37**: 15–90. 1956.

KOBUSKI, CLARENCE E. Studies in the Theaceae, XXVIII. Melchiora, a new genus in Africa. Jour. Arnold Arb. **27**: 153–159. 1956.

MCKELVEY, SUSAN DELANO. Botanical exploration of the Trans-Mississippi West 1790–1850. *i–xl*, 1–1144, 11 maps. 1956.

SAX, KARL. Evaluation of recombination theory. Jour. Cell. & Comp. Physiol. **45**: 243–247. 1955.

——— Paste the poison ivy. Arnoldia **16**: 5–8, *pl. 2*. 1956.

——— Pflanzenzuchtung im Arnold Arboretum. Deutsche Baumschule **7**: 177–183. 1955.

——— Standing room only. Boston, Beacon Press. 1–206. 1955.

——— The story behind dwarf fruits. Horticulture **34**: 203, 233. 1956.

——— What is new in plant propagation? Nat. Hort. Mag. **35**: 116–118. 1956.

——— & ALAN Q. DICKSON. Phloem polarity and bark regeneration. Jour. Arnold Arb. **37**: 173–179. 1956.

SCHWARTEN, LAZELLA. Index to American Botanical Literature. Bull. Torrey Bot. Club **82**: 313–323, 407–418, 511–524, 1955; **83**: 84–92, 174–181, 241–251. 1956.

WOOD, CARROLL E., JR. (with R. A. Howard) Christmas plants in the Boston Area. Arnoldia **15**: 61–84, *pl. 11–14*. 1955.

WYMAN, DONALD. Arboretum spring planting notes. Arnoldia **16**: 17–27, *pl. 6–8*. 1956.

——— Cotoneasters. Arnoldia **15**: 53–60, *pl. 9, 10*. 1956.

——— Crab apples for America. Am. Assoc. Bot. Gardens & Arboretums. 1–63. 1955.

——— Eighty trees for the small place. Arnoldia **16**: 9–15, *pl. 3–5*. 1956.

——— Ground cover plants. New York, Macmillan Co., 1–175, *illust.* 1956.

——— Ground covers. Nat. Hort. Mag. **35**: 76–79, *illust.* 1956.

——— Ground covers to the rescue. Flower Grower **42**: 61, 72–73, *illust.* 1955.

——— Potentilla fruticosa — A common but little known plant. Arnoldia **15**: 45–52, *pl. 7, 8*. 1955.

——— Ten shrubs that are outstanding. Horticulture **33**: 429, 445, 453, *illust.* 1955.

RICHARD A. HOWARD,
Director.

Staff of the Arnold Arboretum
1955–1956

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Donald Wyman, Ph.D., Horticulturist.

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